Analysis of MRI by fractals for prediction of sensory attributes: A case study in loin
This study investigates the use of fractal algorithms to analyse MRI of meat products, specifically loin, in order to determine sensory parameters of loin. For that, the capability of different fractal algorithms was evaluated (Classical Fractal Algorithm, CFA; Fractal Texture Algorithm, FTA and One Point Fractal Texture Algorithm, OPFTA). Moreover, the influence of the acquisition sequence of MRI (Gradient echo, GE; Spin Echo, SE and Turbo 3D, T3D) and the predictive technique of data mining (Isotonic regression, IR and Multiple Linear regression, MLR) on the accuracy of the prediction was analysed. Results on this study firstly demonstrate the capability of fractal algorithms to analyse MRI from meat product. Different combinations of the analysed techniques can be applied for predicting most sensory attributes of loins adequately (R > 0.5). However, the combination of SE, OPFTA and MLR offered the most appropriate results. Thus, it could be proposed as an alternative to the traditional food technology methods.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Image Analysis & Computer Graphics, University of Extremadura, University of Copenhagen
Authors: Caballero, D. (Ekstern), Antequera, T. (Ekstern), Caro, A. (Ekstern), Amigo, J. M. (Ekstern), Ersbøll, B. K. (Intern), Dahl, A. B. (Intern), Pérez-Palacios, T. (Ekstern)
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Main Research Area: Technical/natural sciences

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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.71 SJR 1.479 SNIP 1.842
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.467 SNIP 1.873 CiteScore 3.58
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.524 SNIP 1.975 CiteScore 3.44
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.348 SNIP 1.908 CiteScore 3.1
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.394 SNIP 1.993 CiteScore 2.84
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.329 SNIP 1.922 CiteScore 2.84
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.439 SNIP 1.793
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.411 SNIP 1.623
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Computing segmentations directly from x-ray projection data via parametric deformable curves: Paper

We describe an efficient algorithm that computes a segmented reconstruction directly from x-ray projection data. Our algorithm uses a parametric curve to define the segmentation. Unlike similar approaches which are based on level-sets, our method avoids a pixel or voxel grid; hence the number of unknowns is reduced to the set of points that define the curve, and attenuation coefficients of the segments. Our current implementation uses a simple closed curve and is capable of separating one object from the background. However, our basic algorithm can be applied to an arbitrary topology and multiple objects corresponding to different attenuation coefficients in the reconstruction. Through systematic tests we demonstrate a high robustness to the noise, and an excellent performance under a small number of projections.

General information

State: Published
Authors: Dahl, V. A. (Intern), Dahl, A. B. (Intern), Hansen, P. C. (Intern)
Number of pages: 16
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Publication information
Journal: Measurement Science and Technology
Volume: 29
Issue number: 1
Article number: 014003
ISSN (Print): 0957-0233
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.75 SJR 0.668 SNIP 1.173
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.687 SNIP 1.303 CiteScore 1.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.657 SNIP 1.319 CiteScore 1.58
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Convolutional Neural Networks - Generalizability and Interpretations

Sufficient data is key when training Machine Learning algorithms in order to obtain models that generalize for operational use. Sometimes sufficient data is infeasible to obtain and this prevents the use of Machine Learning in many applications. The goal of this thesis is to gain insights and learn from data despite it being limited in amount or context representation. Within Machine Learning this thesis focuses on Convolutional Neural Networks for Computer Vision. The research aims to answer how to explore a model's generalizability to the whole population of data samples and how to interpret the model's function. The thesis presents three overall approaches to gaining insights on generalizability and interpretation. First, one can change the main objective of a problem to study expected insufficiencies and based on this make better a choice of model. For this first approach the thesis presents both a study on translational invariance as well as an example of changing the objective of a problem from classification to segmentation to robustly extract lower level information. The second approach is the use of simulated data which can help by inferring knowledge in our model if real data is scarce. The results show clear advantages both when using rendered Synthetic Aperture Radar images, but also when predictions...
from physical models are used as target variables which are matched with real data to form a large dataset. The third approach to cope with data insufficiencies is to visualize and understand the internal representations of a model. This approach is explored and concrete examples of learnings that can be obtained are shown. There is no doubt that large quantities of well representing data is the best foundation for training Machine Learning models. On the other hand, there are many tools and techniques available to interpret and understand properties of our models. With these at hand we can still learn about our models and use this knowledge to e.g. collect better datasets or improve on the modeling.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Malmgren-Hansen, D. (Intern), Nielsen, A. A. (Intern), Engholm, R. (Ekstern), Skriver, H. (Intern)
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Electronic versions:
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**Relations**
Projects:
Convolutional Neural Networks - Generalizability and Interpretations
Publication: Research › Ph.D. thesis – Annual report year: 2018

**Designing interactively with elastic splines**
We present an algorithm for designing interactively with C1 elastic splines. The idea is to design the elastic spline using a C1 cubic polynomial spline where each polynomial segment is so close to satisfying the Euler-Lagrange equation for elastic curves that the visual difference becomes negligible. Using a database of cubic Bézier curves we are able to interactively modify the cubic spline such that it remains visually close to an elastic spline.

**General information**
State: Accepted/In press
Organisations: Department of Applied Mathematics and Computer Science, Mathematics, Image Analysis & Computer Graphics
Authors: Brander, D. (Intern), Bærentzen, J. A. (Intern), Fisker, A. (Intern), Gravesen, J. (Intern)
Number of pages: 10
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Main Research Area: Technical/natural sciences

**Publication information**
Journal: Computer-Aided Geometric Design
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.55 SJR 0.753 SNIP 1.126
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.961 SNIP 1.618 CiteScore 1.71
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.404 SNIP 2.05 CiteScore 2.09
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.712 SNIP 1.659 CiteScore 1.18
Effects of menopause and high-intensity training on insulin sensitivity and muscle metabolism

To investigate peripheral insulin sensitivity and skeletal muscle glucose metabolism in premenopausal and postmenopausal women, and evaluate whether exercise training benefits are maintained after menopause. Sedentary, healthy, normal-weight, late premenopausal (n=21), and early postmenopausal (n=20) women were included in a 3-month high-intensity exercise training intervention. Body composition was assessed by magnetic resonance imaging and dual-energy x-ray absorptiometry, whole body glucose disposal rate (GDR) by hyperinsulinemic euglycemic clamp (40 mU/m/min), and femoral muscle glucose uptake by positron emission tomography/computed tomography, using the glucose analog fluorodeoxyglucose, expressed as estimated metabolic rate (eMR). Insulin signaling was investigated in muscle biopsies. Age difference between groups was 4.5 years, and no difference was observed in body composition. Training increased lean body mass (estimate [95% confidence interval] 0.5 [0.2-0.9] kg, P...
When performing a line scan using optical coherence tomography (OCT), the distance between the successive scan lines is often large compared to the resolution along each scan line. If two sets of such line scans are acquired orthogonal to each other, intensity values are known along the lines of a square grid, but are unknown inside each square. To view these values as an image, intensities need to be interpolated at regularly spaced pixel positions. In this paper we evaluate three methods for interpolation from grid lines: linear, transfinite and weighted. The linear method does not preserve the known values along the grid lines. The transfinite method, known from mesh generation, preserves the known values but might cause artifacts further away from the grid lines. The weighted method, which we propose, is designed to combine the desired properties of the transfinite method close to grid lines and the stability of the linear method further away. An important parameter influencing the performance of the interpolation methods is the upsampling rate. We perform an extensive evaluation of the three interpolation methods across a range of upsampling rates. Our statistical analysis shows significant difference in the performance of the three methods. We find that the transfinite interpolation works well for small upsampling rates and the proposed weighted interpolation method performs very well for all upsampling rates typically used in practice. On the basis of these findings we propose an approach for combining two OCT scans, acquired such that the lines of the second scan are orthogonal to the first.
Patient-specific estimation of detailed cochlear shape from clinical CT images

A personalized estimation of the cochlear shape can be used to create computational anatomical models to aid cochlear implant (CI) surgery and CI audio processor programming ultimately resulting in improved hearing restoration. The purpose of this work is to develop and test a method for estimation of the detailed patient-specific cochlear shape from CT images. From a collection of temporal bone CT images, we build a cochlear statistical deformation model (SDM), which is a description of how a human cochlea deforms to represent the observed anatomical variability. The model is used for regularization of a non-rigid image registration procedure between a patient CT scan and a CT image, allowing us to estimate the detailed patient-specific cochlear shape. We test the accuracy and precision of the predicted cochlear shape using both CT and CT images. The evaluation is based on classic generic metrics, where we achieve competitive accuracy with the state-of-the-art methods for the task. Additionally, we expand the evaluation with a few anatomically specific scores. The paper presents the process of building and using the SDM of the cochlea. Compared to current best practice, we demonstrate competitive performance and some useful properties of our method.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Bern, Alma IT Systems, Pompeu Fabra University, Technical University of Munich, Scanco Medical AG
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.76 SJR 0.522 SNIP 1.291
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.481 SNIP 1.108 CiteScore 1.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.486 SNIP 1.301 CiteScore 1.79
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.551 SNIP 1.217 CiteScore 1.85
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.417 SNIP 1.099 CiteScore 1.63
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.346 SNIP 0.984 CiteScore 1.4
Scopus rating (2010): SJR 0.313 SNIP 0.792
Scopus rating (2009): SJR 0.178 SNIP 0.295
Scopus rating (2008): SJR 0.159 SNIP 0.259
Scopus rating (2007): SJR 0.162 SNIP 0.294
Original language: English
CT, Cochlear implant, Intracochlear anatomy, Micro-CT, Segmentation, Statistical shape model
DOIs: 10.1007/s11548-017-1701-7
Source: FindIt
Source-ID: 2395240082
Publication: Research - peer-review › Journal article – Annual report year: 2018
Phase function of a spherical particle when scattering an inhomogeneous electromagnetic plane wave

In absorbing media, electromagnetic plane waves are most often inhomogeneous. Existing solutions for the scattering of an inhomogeneous plane wave by a spherical particle provide no explicit expressions for the scattering components. In addition, current analytical solutions require evaluation of the complex hypergeometric function 2F1 for every term of a series expansion. In this work, I develop a simpler solution based on associated Legendre functions with argument zero. It is similar to the solution for homogeneous plane waves but with new explicit expressions for the angular dependency of the far-field scattering components, that is, the phase function. I include recurrence formulae for practical evaluation and provide numerical examples to evaluate how well the new expressions match previous work in some limiting cases. The predicted difference in the scattering phase function due to inhomogeneity is not negligible for light entering an absorbing medium at an oblique angle. The presented theory could thus be useful for predicting scattering behavior in dye based random lasing and in solar cell absorption enhancement.
Porosity and density measurements of sodium acetate trihydrate for thermal energy storage

Sodium acetate trihydrate (SAT) can be used as phase change material in latent heat storage with or without utilizing supercooling. The change of density between liquid to solid state leads to formation of cavities inside the bulk SAT during solidification. Samples of SAT which had solidified from supercooled state at ambient temperature and samples which had solidified with a minimal degree supercooled were investigated. The temperature dependent densities of liquid and the two types of solid SAT were measured with a density meter and a thermomechanical analyzer. The cavities formed inside samples of solid SAT, which had solidified after a high or minimal degree of supercooling, were investigated by X-ray scanning and computer tomography. The apparent density of solid SAT depended on whether it solidified from a supercooled state or not. A sample which solidified from a supercooled liquid contained 15% cavities and had a density of 1.26 g/cm³ at 25 °C. SAT which had solidified with minimal supercooling contained 9% cavities and had a density of 1.34 g/cm³ at 25 °C. The apparent densities of the solid SAT samples were significant lower than the value of solid SAT reported in literature of 1.45 g/cm³. The density of liquid and supercooled SAT with extra water was also determined at different temperatures.

General information
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Organisations: Department of Civil Engineering, Section for Building Energy, Department of Physics, Neutrons and X-rays for Materials Physics, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Zaragoza, Technical University of Denmark, Graz University of Technology
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.78 SJR 1.462 SNIP 1.828
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.734 SNIP 1.898 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.576 SNIP 2.206 CiteScore 3.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.516 SNIP 2.5 CiteScore 3.31
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.54 SNIP 2.432 CiteScore 2.7
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.389 SNIP 2.186 CiteScore 2.83
ISI indexed (2011): ISI indexed yes
Simulation tools for scattering corrections in spectrally resolved X-ray Computed Tomography using McXtrace

Spectral computed tomography is an emerging imaging method that involves using recently developed energy discriminating photon-counting detectors (PCDs). This technique enables measurements at isolated high-energy ranges, in which the dominating undergoing interaction between the x-ray and the sample is the incoherent scattering. The scattered radiation causes a loss of contrast in the results, and its correction has proven to be a complex problem, due to its dependence on energy, material composition, and geometry. Monte Carlo simulations can utilize a physical model to estimate the scattering contribution to the signal, at the cost of high computational time. We present a fast Monte Carlo simulation tool, based on McXtrace, to predict the energy resolved radiation being scattered and absorbed by objects of complex shapes. We validate the tool through measurements using a CdTe single PCD (Multix ME-100) and use it for scattering correction in a simulation of a spectral CT. We found the correction to account for up to 7% relative amplification in the reconstructed linear attenuation. It is a useful tool for x-ray CT to obtain a more accurate material discrimination, especially in the high-energy range, where the incoherent scattering interactions become prevailing (>50 keV).

General information
State: Published
Organisations: Department of Physics, Neutrons and X-rays for Materials Physics, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Busi, M. (Intern), Olsen, U. L. (Intern), Knudsen, E. B. (Intern), Frisvad, J. R. (Intern), Kehres, J. (Intern), Dreier, E. S. (Ekstern)
Number of pages: 10
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Optical Engineering
Volume: 57
Issue number: 3
Article number: 037105
ISSN (Print): 0091-3286
Ratings:
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
With increasing number of more sophisticated tools to acquire data, we are faced with the important question of what matters in the sea of information at hand. This challenge is becoming more prevalent across virtually all scientific disciplines. Improvements over state of the art methods for analysing such data carry the potential to revolutionize tasks such as medical diagnostics where often decisions need to be based on only a few high-dimensional observations. This
explosion in data dimensionality has sparked the development of novel statistical methods. In contrast, classical statistics build upon the assumption that we have more samples than variables, and the main asymptotic results, such as the central limit theorem, reflect that. As the assumption of having many samples does not hold for modern datasets, we need new tools and methods to find the signal within the dataset which is predictive of the relevant response variable. The focus in this thesis is on sparse methods where sparse implies that the method selects only a few variables. Different types of data call for different methods. In this thesis the sparse methods we study concern settings where the response variable is ordinal. Such ordinal labeling is common in many fields, for example, medical doctors often summarize their observations into a single class of disease severity, which is known as a medical rating score. Automation offers the potential to improve both the reliability and objectivity of such tasks. To demonstrate the effectiveness of the sparse methods developed in this thesis, they were applied to both challenging and diverse real-world problems: Predicting the severity of motion disorders from Parkinson’s patients, generating short summaries of content from hundreds of online user reviews and detecting foreign objects from Multispectral X-ray scans. It may be noted, that to achieve these results, novel optimization approaches and open-source software were implemented.

General information
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis
Authors: Einarsson, G. (Intern), Paulsen, R. R. (Intern), Clemmensen, L. K. H. (Intern), Fink-Jensen, A. (Forskerdatabase), Pagsberg, A. K. (Ekstern)
Number of pages: 283
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Main Research Area: Technical/natural sciences

Relations
Projects:
Sparse Classification - Methods & Applications
Publication: Research › Ph.D. thesis – Annual report year: 2018

Statistical validation of individual fibre segmentation from tomograms and microscopy
Imaging with X-ray computed tomography (CT) enables non-destructive 3D characterisations of the micro-structure inside fibre composites. In this paper we validate the use of X-ray CT coupled with image analysis for characterising unidirectional (UD) fibre composites. We compare X-ray CT at different resolutions to optical microscopy (OM) and scanning electron microscopy (SEM), where we characterise fibres by their diameters and positions. In addition to comparing individual fibre diameters, we also model their spatial distribution, and compare the obtained model parameters. Our study shows that X-ray CT is a high precision technique for characterising fibre composites and, with our suggested image analysis method for fibre detection, high precision is also obtained at low resolutions. This has great potential, since it allows larger fields of view to be analysed. Besides analysing representative volumes with high precision, we demonstrate that based on our methodology for individual fibre segmentation it is now possible to study complete bundles at the fibre scale and reveal inhomogeneities in the physical sample.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Department of Wind Energy, Composites and Materials Mechanics
Authors: Emerson, M. J. (Intern), Dahl, V. A. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern), Dahl, A. B. (Intern)
Pages: 208-215
Publication date: 2018
Main Research Area: Technical/natural sciences

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Journal: Composites Science and Technology
Volume: 160
ISSN (Print): 0266-3538
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.37 SJR 1.568 SNIP 2.002
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.487 SNIP 2.015 CiteScore 4.44
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.767 SNIP 2.467 CiteScore 4.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.736 SNIP 2.587 CiteScore 4.56
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.911 SNIP 2.837 CiteScore 4.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.802 SNIP 2.832 CiteScore 3.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.975 SNIP 2.512
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.755 SNIP 2.151
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.879 SNIP 2.293
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.408 SNIP 2.243
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.821 SNIP 2.731
Scopus rating (2005): SJR 1.636 SNIP 2.251
Scopus rating (2004): SJR 1.554 SNIP 1.999
Scopus rating (2003): SJR 1.285 SNIP 1.692
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.881 SNIP 1.626
Scopus rating (2001): SJR 1.392 SNIP 1.424
Scopus rating (2000): SJR 1.101 SNIP 1.187
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.052 SNIP 1.391
Original language: English
Geometrical characterisation, Polymer-matrix composites (PMCs), Glass fibres, Statistics, Non-destructive testing
DOIs:
10.1016/j.compscitech.2018.03.027

Relations
Projects:
Statistical validation of individual fibre segmentation from tomograms and microscopy
Source: PublicationPreSubmission
Source-ID: 145753554
Publication: Research - peer-review › Journal article – Annual report year: 2018
Systematic comparison of different techniques to measure hippocampal subfield volumes in ADNI2

Objective: Subfield-specific measurements provide superior information in the early stages of neurodegenerative diseases compared to global hippocampal measurements. The overall goal was to systematically compare the performance of five representative manual and automated T1 and T2 based subfield labeling techniques in a sub-set of the ADNI2 population.

Methods: The high resolution T2 weighted hippocampal images (T2-HighRes) and the corresponding T1 images from 106 ADNI2 subjects (41 controls, 57 MCI, 8 AD) were processed as follows. A. T1-based: 1. Freesurfer + Large-Diffeomorphic-Metric-Mapping in combination with shape analysis. 2. FreeSurfer 5.1 subfields using in-vivo atlas. B. T2-HighRes: 1. Model-based subfield segmentation using ex-vivo atlas (FreeSurfer 6.0). 2. T2-based automated multi-atlas segmentation combined with similarity-weighted voting (ASHS). 3. Manual subfield parcellation. Multiple regression analyses were used to calculate effect sizes (ES) for group, amyloid positivity in controls, and associations with cognitive/memory performance for each approach. Results: Subfield volumetry was better than whole hippocampal volumetry for the detection of the mild atrophy differences between controls and MCI (ES: 0.27 vs 0.11). T2-HighRes approaches outperformed T1 approaches for the detection of early stage atrophy (ES: 0.27 vs.0.10), amyloid positivity (ES: 0.11 vs 0.04), and cognitive associations (ES: 0.22 vs 0.19). Conclusions: T2-HighRes subfield approaches outperformed whole hippocampus and T1 subfield approaches. None of the different T2-HighRes methods tested had a clear advantage over the other methods. Each has strengths and weaknesses that need to be taken into account when deciding which one to use to get the best results from subfield volumetry.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of California at San Francisco, University of Pennsylvania, Northwestern University, University College London, VA Medical Center
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Main Research Area: Technical/natural sciences

Journal: NeuroImage: Clinical
Volume: 17
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Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed Yes
Scopus rating (2016): CiteScore 4.57 SJR 2.245 SNIP 1.296
Scopus rating (2015): SJR 2.158 SNIP 1.124 CiteScore 4.46
Scopus rating (2014): SJR 1.258 SNIP 0.909 CiteScore 2.79
Scopus rating (2013): SJR 0.482 SNIP 0.339 CiteScore 1.25
ISI indexed (2013): ISI indexed no
Original language: English
Electronic versions: 1_s2.0_S2213158217303418_main.pdf
DOI: 10.1016/j.nicl.2017.12.036
Source: Scopus
Source-ID: 85039942117
Publication: Research - peer-review › Journal article – Annual report year: 2018

Three Dimensional Polarimetric Neutron Tomography of Magnetic Fields
Through the use of Time-of-Flight Three Dimensional Polarimetric Neutron Tomography (ToF 3DPNT) we have for the first time successfully demonstrated a technique capable of measuring and reconstructing three dimensional magnetic field strengths and directions unobtrusively and non-destructively with the potential to probe the interior of bulk samples which is not amenable otherwise. Using a pioneering polarimetric set-up for ToF neutron instrumentation in combination with a newly developed tailored reconstruction algorithm, the magnetic field generated by a current carrying solenoid has been measured and reconstructed, thereby providing the proof-of-principle of a technique able to reveal hitherto unobtainable information on the magnetic fields in the bulk of materials and devices, due to a high degree of penetration into many materials, including metals, and the sensitivity of neutron polarisation to magnetic fields. The technique puts the potential of the ToF time structure of pulsed neutron sources to full use in order to optimise the recorded information quality and reduce measurement time.

General information
Towards Interactive Photorealistic Rendering

Interactive rendering applications are becoming more and more prominent in everyday life. In many fields, including manufacturing, product design and entertainment, photorealistic rendering is useful in predicting the appearance of complex materials. However, due to production and time constraints, applications need to be interactive to provide immediate feedback to the user.

In this thesis, we address this challenge by proposing new photorealistic interactive rendering techniques, that leverage the parallel power of graphics processing units (GPUs) in order to effectively create renderings based on the laws of physics. These techniques propose effective caching and filtering schemes in order to efficiently reuse data, either across space or across time. We provide insights into different areas of computer graphics, including scene reconstruction, material parameter estimation, efficient data structures and physically based rendering models. Our goal is to explore the different compromises and trade-offs that are necessary to achieve accurate photorealistic renderings.
Contribute with two techniques: the first relates to fast rendering of translucent materials, accounting for directional effects of subsurface scattering. The second technique contributes with a fast reprojection scheme to improve temporal stability in interactive ray tracing, that can be applied on top of existing rendering algorithms. On top of these, we propose an innovative validation pipeline to compare renderings with actual images, with the final purpose of validating existing rendering and reconstruction techniques against a picture of the real world.

With these contributions, we demonstrate how it is possible to use effective caching schemes to effectively improve existing techniques to handle more complex optical effects, maintaining the time constraints of interactive rendering environments.

General information
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Dal Corso, A. (Intern)
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Visual Human-Computer Interaction
In the recent years, technologies such as Virtual and Augmented Reality has gained massive popularity. Simultaneously, computer vision systems and computation power have reached a point, where it is possible to acquire and process geometric and appearance data to produce photorealistic renderings that can appear indistinguishable from real photographs. This enables new ways for Human-Computer Interaction (HCI) methods and applications, that needs to be evaluated to explore their full potential. This thesis addresses a set of vision based challenges concerning HCI. The presented contributions fall into the overall themes of geometric acquisition and handling of refractive objects, photorealistic rendering for computer graphics applications, and systems for advanced and realistic complex applications for HCI. Accordingly, the work of this thesis is presented in a four-element taxonomy: Geometry and appearance acquisition, tracking, visualization and interaction, and datasets. The work contributes to state of the art methods and prepares the ground for future research within the above-mentioned topics. All in all this thesis contributes to improving the field of visual HCI.

General information
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Rector's office
Authors: Stets, J. D. (Intern), Aanaes, H. (Intern), Larsen, R. (Intern)
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Corticomuscular coherence in the acute and subacute phase after stroke
Objective Stroke is one of the leading causes of physical disability due to damage of the motor cortex or the corticospinal tract. In the present study we set out to investigate the role of adaptations in the corticospinal pathway for motor recovery during the subacute phase after stroke. Methods We examined 19 patients with clinically diagnosed stroke and 18 controls. The patients had unilateral mild to moderate weakness of the hand. Each patient attended two sessions at
approximately 3 days (acute) and 38 days post stroke (subacute). Task-related changes in the communication between motor cortex and muscles were evaluated from coupling in the frequency domain between EEG and EMG during movement of the paretic hand. Results Corticomuscular coherence (CMC) and intermuscular coherence (IMC) were reduced in patients as compared to controls. Paretic hand motor performance improved within 4–6 weeks after stroke, but no change was observed in CMC or IMC. Conclusions CMC and IMC were reduced in patients in the early phase after stroke. However, changes in coherence do not appear to be an efficient marker for early recovery of hand function following stroke. Significance This is the first study to demonstrate sustained reduced coherence in acute and subacute stroke.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Larsen, L. H. (Ekstern), Zibrandtsen, I. C. (Ekstern), Wienecke, T. (Ekstern), Kjaer, T. W. (Ekstern), Christensen, M. S. (Intern), Nielsen, J. B. (Ekstern), Langberg, H. (Ekstern)
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Scopus rating (2016): CiteScore 2.61 SJR 2.514 SNIP 2.033
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.572 SNIP 0.437 CiteScore 2.61
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.122 SNIP 1.468 CiteScore 3
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.168 SNIP 0.302 CiteScore 3.03
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.133 SNIP 0.366 CiteScore 3.35
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.102 SNIP 0.011
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.307 SNIP 0.352
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
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Corticomuscular coherence, Hemiparesis, Intermuscular coherence, Ischemic stroke, Motor recovery, Subacute phase

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Source-ID: 85030664908
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SCANNING AND TRACKING MONITORING APPARATUS AND METHOD
Disclosed is a scanning monitoring apparatus for medical imaging, the scanning monitoring apparatus comprising a controller unit and a display, wherein the controller unit during a scanning session is configured to obtain tracking data (102) of a subject in a medical scanner, obtain scanner data indicative of operating parameters of the medical scanner (104); determine an output of a verification function based on the tracking data and the scanner data (106); and control the scanning monitoring apparatus according to the output of the verification function (108). A notification signal may be provided if the output is indicative of an erroneous scanning.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Olesen, O. V. (Intern), Benjaminsen, C. (Intern)
Publication date: 22 Jun 2017

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Main Research Area: Technical/natural sciences
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Publication: Research › Patent – Annual report year: 2017

Image quality transfer and applications in diffusion MRI
This paper introduces a new computational imaging technique called image quality transfer (IQT). IQT uses machine learning to transfer the rich information available from one-off experimental medical imaging devices to the abundant but lower-quality data from routine acquisitions. The procedure uses matched pairs to learn mappings from low-quality to corresponding high-quality images. Once learned, these mappings then augment unseen low quality images, for example by enhancing image resolution or information content. Here, we demonstrate IQT using a simple patch-regression implementation and the uniquely rich diffusion MRI data set from the human connectome project (HCP). Results highlight potential benefits of IQT in both brain connectivity mapping and microstructure imaging. In brain connectivity mapping, IQT reveals, from standard data sets, thin connection pathways that tractography normally requires specialised data to reconstruct. In microstructure imaging, IQT shows potential in estimating, from standard “single-shell” data (one non-zero b-value), maps of microstructural parameters that normally require specialised multi-shell data. Further experiments show strong generalisability, highlighting IQT’s benefits even when the training set does not directly represent the application domain. The concept extends naturally to many other imaging modalities and reconstruction problems.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University College London, Microsoft USA, University of Oxford, University of Nottingham
PET/MRI in the presence of metal implants: Completion of the attenuation map from PET emission data

We present a novel technique for accurate whole-body attenuation correction in the presence of metallic endoprosthesis, on integrated non-time-of-flight (non-TOF) PET/MRI scanners. The proposed implant PET-based attenuation map completion (IPAC) method performs a joint reconstruction of radioactivity and attenuation from the emission data to determine the position, shape, and linear attenuation coefficient (LAC) of metallic implants. Methods: The initial estimate of the attenuation map was obtained using the MR Dixon method currently available on the Siemens Biograph mMR scanner. The attenuation coefficients in the area of the MR image subjected to metal susceptibility artifacts are then reconstructed from the PET emission data using the IPAC algorithm. The method was tested on 11 subjects presenting 13 different metallic implants, who underwent CT and PET/MR scans. Relative mean LACs and Dice similarity coefficients were calculated to determine the accuracy of the reconstructed attenuation values and the shape of the metal implant, respectively. The reconstructed PET images were compared with those obtained using the reference CT-based approach and the Dixon-based method. Absolute relative change (aRC) images were generated in each case, and voxel-based analyses were performed. Results: The error in implant LAC estimation, using the proposed IPAC algorithm, was 15.7%± 7.8%, which was significantly smaller than the Dixon- (100%) and CT-(39%) derived values. A mean Dice similarity coefficient of 73% ± 9% was obtained when comparing the IPAC- with the CT-derived implant shape. The voxel-based analysis of the reconstructed PET images revealed quantification errors (aRC) of 13.2% ± 22.1% for the IPAC with respect to CT-corrected images. The Dixon-based method performed substantially worse, with a mean aRC of 23.1% ± 38.4%. Conclusion: We have presented a non-TOF emission-based approach for estimating the attenuation map in the presence of metallic implants, to be used for whole-body attenuation correction in integrated PET/MR scanners. The Graphics Processing Unit implementation of the algorithm will be included in the open-source reconstruction toolbox Occiput.io.

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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 5.06 SJR 2.261 SNIP 1.804
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
A comparison of reflectance properties on polymer micro-structured functional surface

In this study, a functional micro-structure surface [1] has been developed as a combination of arrays of micro ridges. The scope of the surface is to achieve specific directional optical properties: that is, under constrained lighting, maximizing the reflectance from a certain viewing direction, and minimizing it from the corresponding horizontally orthogonal position, i.e. maximize the contrast between two horizontally orthogonal view positions at the same inclination (Figure 1). The sample is composed of 12 different anisotropic surfaces, that are designed as a combination of ridges defined by their pitch distance and their angle in respect to the surface (Figure 2). The geometry was obtained by precision milling of a tool steel bar and replicated through silicone replica technology [2], and by hot embossing using Acrylonitrile Butadiene Styrene (ABS). A digital microscope has been used as a gonioreflectometer to determine the directional surface reflectance of each surface to varying light and camera positions. The presented results show that the replication processes and the polymeric material have a strong impact on the contrast under constrained lightening. More specifically, the reflectance properties are strongly influenced by the geometry of the structure and by the colour.

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State: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Danish Meteorological Institute
A machine learning method for fast and accurate characterization of depth-of-interaction gamma cameras: Paper

Measuring the depth-of-interaction (DOI) of gamma photons enables increasing the resolution of emission imaging systems. Several design variants of DOI-sensitive detectors have been recently introduced to improve the performance of scanners for positron emission tomography (PET). However, the accurate characterization of the response of DOI detectors, necessary to accurately measure the DOI, remains an unsolved problem. Numerical simulations are, at the state of the art, imprecise, while measuring directly the characteristics of DOI detectors experimentally is hindered by the impossibility to impose the depth-of-interaction in an experimental set-up. In this article we introduce a machine learning approach for extracting accurate forward models of gamma imaging devices from simple pencil-beam measurements, using a nonlinear dimensionality reduction technique in combination with a finite mixture model. The method is purely data-driven, not requiring simulations, and is applicable to a wide range of detector types. The proposed method was evaluated both in a simulation study and with data acquired using a monolithic gamma camera designed for PET (the cMiCE detector), demonstrating the accurate recovery of the DOI characteristics. The combination of the proposed calibration technique with maximum-a posteriori estimation of the coordinates of interaction provided a depth resolution of approximate to 1.14 mm for the simulated PET detector and approximate to 1.74 mm for the cMiCE detector. The software and experimental data are made available at http://occiput.mgh.harvard.edu/depthembedding/.

**General information**

State: Published

Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School, University of Washington

Authors: Pedemonte, S. (Ekstern), Pierce, L. (Ekstern), Van Leemput, K. (Intern)

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BFI (2014): BFI-level 1

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Web of Science (2014): CiteScore 3.16

BFI (2013): BFI-level 1

Scopus rating (2013): CiteScore 3.4

ISI indexed (2013): ISI indexed yes

Web of Science (2013): CiteScore 3.12

BFI (2012): BFI-level 1

Scopus rating (2012): CiteScore 3.12
A method to characterize the roughness of 2-D line features: recrystallization boundaries

A method is presented, which allows quantification of the roughness of nonplanar boundaries of objects for which the neutral plane is not known. The method provides quantitative descriptions of both the local and global characteristics. How the method can be used to estimate the sizes of rough features and local curvatures is also presented. The potential of the method is illustrated by quantification of the roughness of two recrystallization boundaries in a pure Al specimen characterized by scanning electron microscopy.

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Volume: 265
Issue number: 3
ISSN (Print): 0022-2720
Ratings:
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A Monte Carlo simulation of scattering reduction in spectral x-ray computed tomography

In X-ray computed tomography (CT), scattered radiation plays an important role in the accurate reconstruction of the inspected object, leading to a loss of contrast between the different materials in the reconstruction volume and cupping artifacts in the images. We present a Monte Carlo simulation tool for spectral X-ray CT to predict the scattered radiation generated by complex samples. An experimental setup is presented to isolate the energy distribution of scattered radiation. Spectral CT is a novel technique implementing photon-counting detectors able to discriminate the energy of
incoming photons, enabling spectral analysis of X-ray images. This technique is useful to extract efficiently more information on energy dependent quantities (e.g. mass attenuations coefficients) and study matter interactions (e.g. X-ray scattering, photoelectric absorption, etc...). Having a good knowledge of the spectral distribution of the scattered X-rays is fundamental to establish methods attempting to correct for it. The simulations are validated by real measurements using a CdTe spectral resolving detector (Multix ME-100). We observed the effect of the scattered radiation on the image reconstruction, becoming relevant in the energy range where the Compton events are dominant (i.e. above 50keV).

General information
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Organisations: Department of Physics, Neutrons and X-rays for Materials Physics, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Niels Bohr Institute
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ISSN: 0277-786X
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DOIs: 10.1117/12.2273763
Source: FindIt
Source-ID: 2392925020
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

An Error Analysis of Structured Light Scanning of Biological Tissue
This paper presents an error analysis and correction model for four structured light methods applied to three common types of biological tissue; skin, fat and muscle. Despite its many advantages, structured light is based on the assumption of direct reflection at the object surface only. This assumption is violated by most biological material e.g. human skin, which exhibits subsurface scattering. In this study, we find that in general, structured light scans of biological tissue deviate significantly from the ground truth. We show that a large portion of this error can be predicted with a simple, statistical linear model based on the scan geometry. As such, scans can be corrected without introducing any specially designed pattern strategy or hardware. We can effectively reduce the error in a structured light scanner applied to biological tissue by as much as factor of two or three.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Jensen, S. H. N. (Intern), Wilm, J. (Intern), Aanæs, H. (Intern)
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3D reconstruction, Error modeling, Structured light
Electronic versions:

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DOIs:
An image-based method for objectively assessing injection moulded plastic quality

In high volume productions based on casting processes, like high-pressure die casting (HPDC) or injection moulding, there is a wide range of variables that affect the end quality of produced parts. These variables include production parameters (temperature, pressure, mixture), and external factors (humidity, temperature, etc.). With this many variables it is a challenge to maintain a stable output quality, wherefore massive amounts of resources are spent on quality assurance (QA) of produced parts. Currently, this QA is done manually through visual inspection. We demonstrate how a multispectral imaging system can be used to automatically rate the quality of a produced part using an autocorrelation and a Fourier-based method. These methods are compared with human rankings and achieve good correlations on a variety of samples.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Budapest University of Technology and Economics
Authors: Hannemose, M. (Intern), Nielsen, J. B. (Intern), Zsíros, L. (Ekstern), Aanæs, H. (Intern)
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Publication date: 2017

An Investigation of Methods for CT Synthesis in MR-only Radiotherapy

In recent years, the interest in using magnetic resonance (MR) imaging in radiotherapy (RT) has increased. This is because MR has a superior soft tissue contrast compared to computed tomography (CT), which makes it a better modality for delineating the target volume (tumor) and possible organs at risk (OARs). In an MR/CT work-flow, independent MR and CT scans are acquired. The target and possible OARs are delineated on the MR and then transferred to CT by aligning the data using a registration. This introduces the risk of systematic registration errors especially in non-rigid body structures, the consequence being a systematic miss of target or increased dose to healthy tissue.

Radiotherapy based on MR as the only modality removes this uncertainty and simplifies the clinical work-flow. However, the information on electron density which is usually contained in the CT must now be derived from the MR. A way to achieve this is to computationally estimate a so-called synthetic CT (sCT) from the MR data, which can then act as a substitute for the CT. This is a challenging task, since no unique relationship between MR and electron density exists.

The goal of this thesis is to develop and investigate the right combination of MR acquisition protocols and computational models for accurate MR-based CT synthesis for use in RT. We investigate different categories of methods for CT synthesis and validate them using clinically relevant quality measures. Specifically, we implement a patch-based multi-atlas method in the brain, which compares favorably to state-of-the-art methods. In our next effort, we substantially improve the speed of the method and apply it in the pelvis, again with promising results. Our final contribution is a voxel-based method, which is developed to be registration-free and broadly applicable. In initial results, the performance of this method is close to the patch-based.

General information
Anthropometry, DXA and leptin reflect subcutaneous but not visceral abdominal adipose tissue by MRI in 197 healthy adolescents

Background Abdominal fat distribution is associated with the development of cardio-metabolic disease independently of body mass index (BMI). We assessed anthropometry, serum adipokines, and DXA as markers of abdominal subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) using magnetic resonance imaging (MRI). Methods We performed a cross-sectional study that included 197 healthy adolescents (114 boys) aged 10–15 years nested within a longitudinal population-based cohort. Clinical examination, blood sampling, DXA, and abdominal MRI were performed. SAT% and VAT% were adjusted to total abdominal volume. Results Girls had a higher SAT% than did boys in early and late puberty (16 vs. 13%, P<0.01 and 20 vs. 15%, P=0.001, respectively), whereas VAT% was comparable (7% in both genders, independently of puberty). DXA android fat% (standard deviation score (SDS)), suprailiac skinfold thickness (SDS), leptin, BMI (SDS), waist-to-height ratio (WHtR), and waist circumference (SDS) correlated strongly with SAT% (descending order: r=0.90–0.55, all P<0.001) but weakly with VAT% (r=0.49–0.06). Suprailiac skinfold was the best anthropometric marker of SAT% (girls: R²=48.6%, boys: R²=65%, P<0.001) and VAT% in boys (R²=16.4%, P<0.001). WHtR was the best marker of VAT% in girls (R²=7.6%, P=0.007). Conclusions Healthy girls have a higher SAT% than do boys, whereas VAT% is comparable, independently of puberty. Anthropometry and circulating leptin are valid markers of SAT%, but not of VAT%.

General information
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Organisations: Department of Applied Mathematics and Computer Science, University of Copenhagen
Authors: Tinggaard, J. (Ekstern), Hagen, C. P. (Ekstern), Christensen, A. N. (Intern), Mouritsen, A. (Ekstern), Mieritz, M. G. (Ekstern), Wohlfahrt-Veje, C. (Ekstern), Helge, J. W. (Ekstern), Beck, T. N. (Ekstern), Fallentin, E. (Ekstern), Larsen, R. (Intern), Jensen, R. B. (Ekstern), Juul, A. C. (Ekstern), Main, K. M. (Ekstern)
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 2.88 SJR 1.398 SNIP 1.062
Web of Science (2016): Indexed yes
A performance assessment of a 2 axis scanning mirror galvanometer for powder bed fusion

Additive Manufacturing by powder bed fusion allows production of high strength parts with complex features, not possible through conventional manufacturing. To experiment and test current theory within laser processing of metal powder, an open and customizable laser scanner platform is developed and constructed. The platform seeks to fully support and enable the laser driven process of selective consolidation metal powder, as most industrially available powder bed fusion machine tools are closed and proprietary systems. This allows the machine tool manufacturer to strictly control how the system is used and therefore maintainstability through limiting the operator to use proprietary software hardware and process materials but unfortunately limits to an equally wide extent how such machine tools can be applied for research purposes as it renders the scientist to become a mere operator of the machine tool. A galvanometer based laser scanning system is here presented. The system was designed to meet a theoretical resolution of 0.009 mm. From inspiration of the use of optomechanical hole plates as reference artefacts for coordinate metrology a test was conducted to verify the accuracy of the laser scanning system. The system was found to perform excellent for relative positioning. Absolute positioning of the laser beam did not conform with design specifications, as the test deviated by 0.12 mm with respect to the nominal test value, yet this is expected in the future to be met from the implementation of a better galvanometer control system.

General information
A Probabilistic Framework for Curve Evolution
In this work, we propose a nonparametric probabilistic framework for image segmentation using deformable models. We estimate an underlying probability distributions of image features from regions defined by a deformable curve. We then evolve the curve such that the distance between the distributions is increasing. The resulting active contour resembles a well studied piecewise constant Mumford-Shah model, but in a probabilistic setting. An important property of our framework is that it does not require a particular type of distributions in different image regions. Additional advantages of our approach include ability to handle textured images, simple generalization to multiple regions, and efficiency in computation. We test our probabilistic framework in combination with parametric (snakes) and geometric (level-sets) curves. The experimental results on composed and natural images demonstrate excellent properties of our framework.

Augmented Reality Interfaces for Additive Manufacturing
This paper explores potential use cases for using augmented reality (AR) as a tool to operate industrial machines. As a baseline we use an additive manufacturing system, more commonly known as a 3D printer. We implement novel augmented interfaces and controls using readily available open source frameworks and low cost hardware. Our results show that the technology enables richer and more intuitive printer control and performance monitoring than currently available on the market. Therefore, there is a great deal of potential for these types of technologies in future digital factories.
Automatic Segmentation of Abdominal Fat in MRI-Scans, Using Graph-Cuts and Image Derived Energies
For many clinical studies changes in the abdominal distribution of fat is an important measure. However, the segmentation of abdominal fat in MRI scans is both difficult and time consuming using manual methods. We present here an automatic and flexible software package, that performs both bias field correction and segmentation of the fat into superficial and deep subcutaneous fat as well as visceral fat with the spinal compartment removed. Assessment when comparing to the gold standard - CT-scans - shows a correlation and bias comparable to manual segmentation. The method is flexible by tuning the image-derived energies used for the segmentation, allowing the method to be applied to other body parts, such as the thighs.

A variational study on BRDF reconstruction in a structured light scanner
Time-efficient acquisition of reflectance behavior together with surface geometry is a challenging problem. In this study, we investigate the impact of system parameter uncertainties when incorporating a data-driven BRDF reconstruction approach into the standard pipeline of a structured light scanning system. The parameters investigated include geometric detail of scanned objects; vertex positions and normals; and position and intensity of light sources. To have full control of
uncertainties, experiments are carried out in a simulated environment, mimicking an actual structured light scanning setup. Results show that while uncertainties in vertex positions and normals have a high impact on the quality of reconstructed BRDFs, object geometry and light source properties have very little influence on the reconstructed BRDFs. With this analysis, practitioners now have insight in the tolerances required for accurate BRDF acquisition to work.

**Cache-mesh, a Dynamics Data Structure for Performance Optimization**

This paper proposes the cache-mesh, a dynamic mesh data structure in 3D that allows modifications of stored topological relations effortlessly. The cache-mesh can adapt to arbitrary problems and provide fast retrieval to the most-referred-to topological relations. This adaptation requires trivial extra effort in implementation with the cache-mesh, whereas it may require tremendous effort using traditional meshes. The cache-mesh also gives a further boost to the performance with parallel mesh processing by caching the partition of the mesh into independent sets. This is an additional advantage of the cache-mesh, and the extra work for caching is also trivial. Though it appears that it takes effort for initial implementation, building the cache-mesh is comparable to a traditional mesh in terms of implementation.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Nielsen, J. B. (Intern), Stets, J. D. (Intern), Lyngby, R. A. (Intern), Aanæs, H. (Intern), Dahl, A. B. (Intern), Frisvad, J. R. (Intern)
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Scopus rating (2014): CiteScore 0.53
Scopus rating (2013): CiteScore 0.4
ISI indexed (2013): ISI indexed no
Scopus rating (2012): CiteScore 0.28
ISI indexed (2012): ISI indexed no
Scopus rating (2011): CiteScore 0.45
ISI indexed (2011): ISI indexed no
Canonical analysis of sentinel-1 radar and sentinel-2 optical data
This paper gives results from joint analyses of dual polarimetry synthetic aperture radar data from the Sentinel-1 mission and optical data from the Sentinel-2 mission. The analyses are carried out by means of traditional canonical correlation analysis (CCA) and canonical information analysis (CIA). Where CCA is based on maximising correlation between linear combinations of the two data sets, CIA maximises mutual information between the two. CIA is a conceptually more pleasing method for the analysis of data with very different modalities such as radar and optical data. Although a little inconclusive as far as the change detection aspect is concerned, results show that CIA analysis gives conspicuously less noisy appearing images of canonical variates (CVs) than CCA. Also, the 2D histogram of the mutual information based leading CVs clearly reveals much more structure than the correlation based one. This gives promise for potentially better change detection results with CIA than can be obtained by means of CCA.

Change detection in a series of Sentinel-1 SAR data
Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a time series of seven multilook, dual polarization Sentinel-1 SAR data in the covariance matrix representation (with diagonal elements only) is carried out. The omnibus test statistic and its factorization detect if and when change occurs.

Change detection in multi-temporal dual polarization Sentinel-1 data

Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a time series of 19 multilook, dual polarization Sentinel-1 SAR data in the covariance matrix representation (with diagonal elements only) is carried out. The omnibus test statistic and its factorization detect if and when change occurs.

Characterization of the glucagon-like peptide-1 receptor in male mouse brain using a novel antibody and in situ hybridization

Glucagon-like peptide-1 (GLP-1) is a physiological regulator of appetite and long-acting GLP-1 receptor agonists (GLP-1RA) lower food intake and bodyweight in both human and animal studies. The effects are mediated through brain GLP-1Rs, and several brain nuclei expressing the GLP-1R may be involved. To date, mapping the complete location of GLP-1R protein in the brain has been challenged by lack of good antibodies and the discrepancy between mRNA and protein especially relevant in neuronal axonal processes. Here, we present a novel and specific monoclonal GLP-1R antibody for immunohistochemistry with murine tissue and show detailed distribution of GLP-1R expression as well as mapping of GLP-1R mRNA by non-radioactive in situ hybridization. Semi-automated image analysis was performed to map the GLP-1R distribution to atlas plates from the Allen Institute of Brain Science (AIBS). The GLP-1R was abundantly expressed in numerous regions including the septal nucleus, the hypothalamus and the brain stem. GLP-1R protein expression was also observed on neuronal projections in brain regions devoid of any mRNA which has not been observed in earlier reports. Taken together, these findings provide new knowledge on GLP-1R expression in neuronal cell bodies and neuronal projections.
Combined shape and topology optimization for minimization of maximal von Mises stress
This work shows that a combined shape and topology optimization method can produce optimal 2D designs with minimal stress subject to a volume constraint. The method represents the surface explicitly and discretizes the domain into a simplicial complex which adapts both structural shape and topology. By performing repeated topology and shape optimizations and adaptive mesh updates, we can minimize the maximum von Mises stress using the p-norm stress measure with p-values as high as 30, provided that the stress is calculated with sufficient accuracy.
Combined shape and topology optimization, Deformable simplicial complex method, Explicit surface representation, Stress minimization
Computational Modeling of Medical Images of Brain Tumor Patients for Optimized Radiation Therapy Planning

In brain tumor radiation therapy, the aim is to maximize the delivered radiation dose to the targeted tumor and at the same time minimize the dose to sensitive healthy structures – so-called organs-at-risk (OARs). When planning a radiation therapy session, the tumor and the OARs therefore need to be delineated on medical images of the patient’s head, to be able to optimize a radiation dose plan. In clinical practice, the delineation is performed manually with limited assistance from automatic procedures, which is both time-consuming and typically suffers from poor reproducibility. There is, therefore, a need for automated methods that can segment both brain tumors and OARs. However, there is a noticeable lack in the literature of methods that simultaneously segment both types of structures.

To automatically segment medical images of brain tumor patients is difficult because brain tumors vary greatly in size, shape, appearance and location within the brain. Furthermore, healthy structures surrounding a tumor are pushed and deformed by the so-called mass effect of the tumor. Moreover, medical imaging techniques often result in imaging artifacts and varying intensity across imaging centers.

The goal of this PhD-project was to develop automated segmentation methods that can handle both brain tumors and OARs. In the first part of the project, we developed a model for tumor shape and used it to develop a fully automated generative method specifically for brain tumor segmentation. This method performed favorably compared to other state-of-the-art methods. In the second part of the project, we used a probabilistic atlas-based model capable of detailed modeling of the spatial organization in a healthy brain, and extended it to handle various OARs. We incorporated this model into the previously used modeling framework. In experiments, we showed that the resulting model was capable of simultaneous segmentation of brain tumors and OARs, while also being capable of adapting to varying image sequences and images from different imaging centers.
machine interaction paradigms within additive manufacturing. Here, challenges are addressed within the 3D ecosystem, aiming towards facilitating a fluid integration of additive manufacturing within the factory of tomorrow.

**General information**
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Manufacturing Engineering
Authors: Eiriksson, E. R. (Intern), Aanæs, H. (Intern), Pedersen, D. B. (Intern)
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**Relations**
Projects:
Computer Vision for Additive Manufacturing.

**Computer Vision in Vehicle Technology: Land, Sea & Air**

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Girona, Yildiz Technical University, French National Centre for Scientific Research
Authors: Gracias, N. (Ekstern), Garcia, R. (Ekstern), Shihavuddin, A. (Intern), Campos, R. (Ekstern), Hurtos, N. (Ekstern), Prados, R. (Ekstern), Nicosevici, T. N. (Ekstern), Elbibol, A. (Ekstern), Neumann, L. (Ekstern), Escartin, J. (Ekstern)
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**Corrections to "Change Detection in Full and Dual Polarization, Single- and Multi-Frequency SAR Data"**
When the covariance matrix formulation is used for multi-look polarimetric synthetic aperture radar (SAR) data, the complex Wishart distribution applies. Based on this distribution a test statistic for equality of two complex variance-covariance matrices and an associated asymptotic probability of obtaining a smaller value of the test statistic are given. In a case study airborne EMISAR C- and L-band SAR images from the spring of 1998 covering agricultural fields and wooded areas near Foulum, Denmark, are used in single- and bi-frequency, bi-temporal change detection with full and dual polarimetry data.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern)
Pages: 5143-5144
Publication date: 2017
Main Research Area: Technical/natural sciences

**Publication information**
Creating Ultra Dense Point Correspondence Over the Entire Human Head

While the acquisition and analysis of 3D faces has been an active area of research for decades, it is still a complex and demanding task to accurately model the entire head and ears. Having accurate models would for example enable virtual design of hearing devices. In this paper, we describe a complete framework for surface registration of complete human heads where the result is point correspondence with a very high number of points. The method is based on a volumetric and multi-scale non-rigid registration of signed distance fields. The method is evaluated on a set of 30 human heads and the results are convincing. The output can for example be used to compute statistical shape models. The accuracy of predicted anatomical landmarks is on the level of experienced human operators.
Data Descriptor: A multiscale imaging and modelling dataset of the human inner ear
Understanding the human inner ear anatomy and its internal structures is paramount to advance hearing implant technology. While the emergence of imaging devices allowed researchers to improve understanding of intracochlear structures, the difficulties to collect appropriate data has resulted in studies conducted with few samples. To assist the cochlear research community, a large collection of human temporal bone images is being made available. This data descriptor, therefore, describes a rich set of image volumes acquired using cone beam computed tomography and micro-CT modalities, accompanied by manual delineations of the cochlea and sub-compartments, a statistical shape model encoding its anatomical variability, and data for electrode insertion and electrical simulations. This data makes an important asset for future studies in need of high-resolution data and related statistical data objects of the cochlea used to leverage scientific hypotheses. It is of relevance to anatomists, audiologists, computer scientists in the different domains of image analysis, computer simulations, imaging formation, and for biomedical engineers designing new strategies for cochlear implantations, electrode design, and others.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Scientific Computing, University of Bern, Alma IT Systems, Scanco Medical AG, MED-EL GMBH, Universitat Pompeu Fabra, University Hospital of Bern, Catalan Institution for Research and Advanced Studies, Technical University of Munich
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Source: FindIt
Source-ID: 2390770382
Publication: Research - peer-review › Journal article – Annual report year: 2017

Development of a New Fractal Algorithm to Predict Quality Traits of MRI Loins
Traditionally, the quality traits of meat products have been estimated by means of physico-chemical methods. Computer vision algorithms on MRI have also been presented as an alternative to these destructive methods since MRI is non-
destructive, non-ionizing and innocuous. The use of fractals to analyze MRI could be another possibility for this purpose. In this paper, a new fractal algorithm is developed, to obtain features from MRI based on fractal characteristics. This algorithm is called OPFTA (One Point Fractal Texture Algorithm). Three fractal algorithms were tested in this study: CFA (Classical fractal algorithm), FTA (Fractal texture algorithm) and OPFTA. The results obtained by means of these three fractal algorithms were correlated to the results obtained by means of physico-chemical methods. OPFTA and FTA achieved correlation coefficients higher than 0.75 and CFA reached low relationship for the quality parameters of loins. The best results were achieved for OPFTA as fractal algorithm (0.837 for lipid content, 0.909 for salt content and 0.911 for moisture). These high correlation coefficients confirm the new algorithm as an alternative to the classical computational approaches (texture algorithms) in order to compute the quality parameters of meat products in a non-destructive and efficient way.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, University of Extremadura, University of Copenhagen
Authors: Caballero, D. (Ekstern), Caro, A. (Ekstern), Amigo, J. M. (Ekstern), Dahl, A. B. (Intern), Ersbøll, B. K. (Intern), Pérez-Palacios, T. (Ekstern)
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Source: FindIt
Source-ID: 2372752209
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Disability in progressive MS is associated with T2 lesion changes
Background: Progressive multiple sclerosis (MS) is characterized by diffuse changes on brain magnetic resonance imaging (MRI), which complicates the use of MRI as a diagnostic and prognostic marker. The relationship between MRI measures (conventional and non-conventional) and clinical disability in progressive MS therefore warrants further investigation. Objective: To investigate the relationship between clinical disability and MRI measures in patients with progressive MS.
Methods: Data from 93 primary and secondary progressive MS patients who had participated in 3 phase 2 clinical trials were included in this cross-sectional study. From 3 T MRI baseline scans we calculated total T2 lesion volume and analysed magnetisation transfer ratio (MTR) and the diffusion tensor imaging indices fractional anisotropy (FA) and mean diffusivity (MD) in T2 lesions, normal-appearing white matter (NAWM) and cortical grey matter. Disability was assessed by the Expanded Disability Status Scale (EDSS) and the MS functional composite. Results: T2 lesion volume was associated with impairment by all clinical measures. MD and MTR in T2 lesions were significantly related to disability, and lower FA values correlated with worse hand function in NAWM. In multivariable analyses, increasing clinical disability was independently correlated with increasing T2 lesion volumes and MTR in T2 lesion. Conclusion: In progressive MS, clinical disability is related to lesion volume and microstructure.

General information
State: Accepted/In press
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Ammitzbøll, C. (Ekstern), Dyrby, T. B. (Intern), Lyksborg, M. (Intern), Schreiber, K. (Ekstern), Ratzer, R. (Ekstern), Christensen, J. R. (Ekstern), Iversen, P. (Ekstern), Magyari, M. (Forskerdatabase), Garde, E. (Ekstern), Sørensen, P. S. (Ekstern), Siebner, H. R. (Ekstern), Sellebjerg, F. (Ekstern)
Publication date: 2017
The use of doubled haploids (DHs) in maize has become ubiquitous in maize breeding programmes as it allows breeders to go from cross to evaluation in as little as 2 years. Two important aspects of the in vivo DH system used in maize are as follows: (i) the identification of haploid progeny and (ii) doubling of the haploid genome to produce fertile inbred lines. This study is focused on the first step. Currently, identification of maize haploid progeny is performed manually using the R1-nj seed colour marker. This is a labour-intensive and time-consuming process; a method for automated sorting of haploids would increase the efficiency of DH line development. In this study, six inbred lines were crossed with the maternal haploid inducer aCRM/RWK-76a€TM and a sample of seed was sorted manually for each line. Using the VideometerLab 3 system, spectral imaging techniques were applied to discriminate between haploids and hybrids. Using DNA markers to confirm the haploid/diploid state of the tested seed, for the majority of genotypes haploid identification was possible with over 50% accuracy.
Effects of imaging gradients in sequences with varying longitudinal storage time—Case of diffusion exchange imaging

Purpose: To illustrate the potential bias caused by imaging gradients in correlation MRI sequences using longitudinal magnetization storage (LS) and examine the case of filter exchange imaging (FEXI) yielding maps of the apparent exchange rate (AXR). Methods: The effects of imaging gradients in FEXI were observed on yeast cells. To analyze the AXR bias, signal evolution was calculated by applying matrix exponential operators. Results: A sharp threshold for the slice thickness was identified, below which the AXR is increasingly underestimated. The bias can be understood in terms of an extended low-pass diffusion filtering during the LS interval, which is more pronounced at lower exchange rates. For a total exchange rate constant larger than 1 s⁻¹, the AXR bias is expected to be negligible when slices thicker than 2.5 mm are used. Conclusion: In correlation experiments like FEXI, relying on LS with variable duration, imaging gradients may cause disrupting effects that cannot be easily mitigated and should be carefully considered for unbiased results. In typical clinical applications of FEXI, the imaging gradients are expected to cause a negligible AXR bias. However, the AXR bias may be significant in preclinical settings or whenever thin imaging slices are used.
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.52 SJR 1.867 SNIP 1.438
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.291 SNIP 1.48 CiteScore 3.54
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.952 SNIP 1.39 CiteScore 3.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.959 SNIP 1.44 CiteScore 3.46
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.072 SNIP 1.549 CiteScore 3.61
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.056 SNIP 1.476 CiteScore 3.45
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.272 SNIP 1.612
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.278 SNIP 1.564
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.382 SNIP 1.512
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.353 SNIP 1.549
Scopus rating (2006): SJR 2.28 SNIP 1.74
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.269 SNIP 1.834
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.121 SNIP 1.719
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.371 SNIP 1.575
Scopus rating (2002): SJR 2.176 SNIP 1.46
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 2.337 SNIP 1.558
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.037 SNIP 1.551
Scopus rating (1999): SJR 2.457 SNIP 2.147
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Radiology, Nuclear Medicine and Imaging, Crusher, Double diffusion encoding, FEXI, Longitudinal storage, Mixing time, Slice, crusher, double diffusion encoding, longitudinal storage, mixing time, slice
DOIs:
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Evaluation of optical functional surfaces on the injection moulding insert by micro milling process

This study presents the optimization of micro milling process for manufacturing injection moulding inserts with an optical functional surface. The objective is to optimize the surface functionality. Micro ridges were used as the microstructures to realize the function to generate contrast between orthogonally textured areas by reflecting light in different directions. In order to maximize the contrast, a sample was machined with the same structures and dimensions, according to a Design of Experiments (DOEs) to optimize the milling parameters by considering the contrast as a response. The contrast was evaluated based on the image processing method. The proper cutting condition was selected in order to obtain machined surface with the highest contrast and the results presented by DOE analysis. The correlations between the cutting parameters, the burrs height, and the function were determined. The contrast was found to be proportional to the spindle speed and feed rate and “oil+air” was considered as the preferred cooling method.

General information
State: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Li, D. (Intern), Davoudinejad, A. (Intern), Zhang, Y. (Intern), Regi, F. (Intern), Tosello, G. (Intern), Nielsen, J. B. (Intern), Aanaes, H. (Intern), Frisvad, J. R. (Intern)
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Title of host publication: Proceedings of the euspen Special Interest Group Meeting: Micro/Nano Manufacturing
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Optical functional surface, Micro milling, Optimization, DOE
Publication: Research - peer-review » Article in proceedings – Annual report year: 2017

Fast, versatile, and non-destructive biscuit inspection system using spectral imaging
A fast, versatile, and non-destructive method for assessing biscuit quality is presented. The method integrates color (or browning) measurement, moisture assessment, compositional and dimensional measurements on a spectral imaging platform using the silicon range 400–1000 nm.

General information
State: Published
Foreign object detection in multispectral X-ray images of food items using sparse discriminant analysis

Non-invasive food inspection and quality assurance are becoming viable techniques in food production due to the introduction of fast and accessible multispectral X-ray scanners. However, the novel devices produce massive amounts of data and there is a need for fast and accurate algorithms for processing it. We apply a sparse classifier for foreign object detection and segmentation in multispectral X-ray. Using sparse methods makes it possible to potentially use fewer variables than traditional methods and thereby reduce acquisition time, data volume and classification speed. We report our results on two datasets with foreign objects, one set with spring rolls and one with minced meat. Our results indicate that it is possible to limit the amount of data stored to 50% of the original size without affecting classification accuracy of materials used for training. The method has attractive computational properties, which allows for fast classification of items in new images.
characterising the orientation and curvature of these individual fibres, which can also provide insights on the interactions amongst the individual fibres. Finite element models (FEMs) can be built from the extracted geometry to simulate the performance of the scanned fibre structure under realistic conditions. Moreover, aspects of the fibre architecture that influence the macroscopic behaviour of the composite can be quantified. Examples are 2D FEMs to predict the transverse stiffness or the quantification of fibre orientations to estimate the compression strength. And last but not least, already developed analytical and numerical models to describe the composite's behaviour can be validated against the observed data.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis
Authors: Emerson, M. J. (Intern), Dahl, V. A. (Intern), Mikkelsen, L. P. (Intern), Dahl, A. B. (Intern), Conradsen, K. (Intern)
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BFI conference series: Nordic Seminar on Computational Mechanics (5010906)
Main Research Area: Technical/natural sciences
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X-ray tomography, Individual Fibres, Unidirectional Composites, Modelling

**Electronic versions**

GEOMETRICAL_CHARACTERISATION.pdf
Publication: Research - peer-review > Conference abstract in proceedings – Annual report year: 2017

Graphite nodules in fatigue-tested cast iron characterized in 2D and 3D

Thick-walled ductile iron casts have been studied by applying (i) cooling rate calculations by FVM, (ii) microstructural characterization by 2D SEM and 3D X-ray tomography techniques and (iii) fatigue testing of samples drawn from components cast in sand molds and metal molds. An analysis has shown correlations between cooling rate, structure and fatigue strengths demonstrating the benefit of 3D structural characterization to identify possible causes of premature fatigue failure of ductile cast iron.

**General information**

State: Published
Organisations: Department of Wind Energy, Materials science and characterization, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Physics, Global Castings A/S, Vestas Wind Systems AS
Authors: Mukherjee, K. (Intern), Fæster, S. (Intern), Hansen, N. (Intern), Dahl, A. B. (Intern), Gundlach, C. (Intern), Frandsen, J. O. (Ekstern), Sturlason, A. (Ekstern)
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Scopus rating (2016): CiteScore 2.75 SJR 1.24 SNIP 1.54
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.242 SNIP 1.606 CiteScore 2.61
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High-resolution magnetic resonance imaging reveals nuclei of the human amygdala: manual segmentation to automatic atlas

The amygdala is composed of multiple nuclei with unique functions and connections in the limbic system and to the rest of the brain. However, standard in vivo neuroimaging tools to automatically delineate the amygdala into its multiple nuclei are still rare. By scanning postmortem specimens at high resolution (100-150µm) at 7T field strength (n = 10), we were able to visualize and label nine amygdala nuclei (anterior amygdaloid, cortico-amygdaloid transition area; basal, lateral, accessory basal, central, cortical medial, paralaminar nuclei). We created an atlas from these labels using a recently developed atlas building algorithm based on Bayesian inference. This atlas, which will be released as part of FreeSurfer, can be used to automatically segment nine amygdala nuclei from a standard resolution structural MR image. We applied this atlas to two publicly available datasets (ADNI and ABIDE) with standard resolution T1 data, used individual volumetric data of the amygdala nuclei as the measure and found that our atlas i) discriminates between Alzheimer's disease participants and age-matched control participants with 84% accuracy (AUC=0.915), and ii) discriminates between individuals with autism and age-, sex- and IQ-matched neurotypically developed control participants with 59.5% accuracy (AUC=0.59). For both datasets, the new ex vivo atlas significantly outperformed (all p <.05) estimations of the whole amygdala derived from the segmentation in FreeSurfer 5.1 (ADNI: 75%, ABIDE: 54% accuracy), as well as classification based on whole amygdala
volume (using the sum of all amygdala nuclei volumes; ADNI: 81%, ABIDE: 55% accuracy). This new atlas and the segmentation tools that utilize it will provide neuroimaging researchers with the ability to explore the function and connectivity of the human amygdala nuclei with unprecedented detail in healthy adults as well as those with neurodevelopmental and neurodegenerative disorders.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Massachusetts Institute of Technology, University College London, Massachusetts General Hospital, Boston University School of Medicine, C.S. Kubik Laboratory for Neuropathology
Authors: Saygin, Z. M. (Ekstern), Kliemann, D. (Ekstern), Iglesias, J. E. (Ekstern), van der Kouwe, A. J. (Ekstern), Boyd, E. (Ekstern), Reuter, M. (Ekstern), Stevens, A. A. (Ekstern), Van Leemput, K. (Intern), McKee, S. A. (Ekstern), Frosch, M. P. (Ekstern), Fischl, B. (Ekstern), Augustinack, J. C. (Ekstern)
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- Web of Science (2016): Indexed yes
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- Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
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- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 3.573 SNIP 1.866
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 3.859 SNIP 1.897
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 4.094 SNIP 1.765
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 3.7 SNIP 1.981
Identification Of Barley Grain Mycoflora By Next Generation Sequencing And Videometer Multispectral Imaging

Seeds of Barley (Hordeum vulgare) are infected by a high number of fungi, including pathogens such as Fusarium graminearum, F. culmorum, F. poae, F. avenaceum and Pyrenophora teres. Fusarium spp. is a widely distributed fungus causing yield reduction in a range of agricultural crops and many species in the genus produce mycotoxins responsible for serious quality deterioration. In malting barley, Fusarium also has a negative effect by causing gushing in beer. A number of barley seeds (app. 200) assumed to be infected by fungal from different origins and years of cultivation were tested by NGS sequencing the ITS (Internal Transcribed Spacer) region from total DNA. Approximately 2-4000 sequences were obtained from each seed and these were subsequently identified to species level in order to give an exact identification of fungal genera on each seed. The main fungal genera identified were Fusarium, Pyrenophora, Epicoccum, Didymella, Alternaria, Bipolaris and Microdochium. The fungal composition and quantities on each seed varied significantly. Some were infected mainly by a single fungus and some were infected by multiple fungi. All seeds were prior to this evaluated by multispectral imaging on the dorsal and ventral sides by the VideometerLab multispectral imaging system (Videometer A/S, Hørsholm, Denmark). This system is an instrument equipped with 19 different light emitting diodes at wavelengths ranging from 375 to 970nm (ultraviolet, visual and lower wavelength of the near-infrared region) in the reflectance mode (5 Mpix per band, pixel size app. 45 μm x 45 μm). Spectral information over the surface of seeds may be combined with information about size, shape, and texture of the seeds. This information links detection of fungal infection with other seed characteristics known from general seed testing. Analytical separation of the identified fungi was based on mean pixel intensity and a normalized Canonical Discriminant Analysis (nCDA) using the images of infected and healthy seeds. The potential of using spectral characteristics of the fungal species as a way to provide a fast optical screening method for fungal contamination of barley on the fungal species level was investigated by comparing results from the next generation sequencing and multispectral imaging.
management solutions. However, very few assessments include effects of the waste composition and waste LCAs often rely on poorly justified data from secondary sources. This study systematically quantifies the influence and uncertainty on LCA results associated with selection of waste composition data. Three archetypal waste management scenarios were modelled with the waste LCA model EASETECH based on detailed waste composition data from the literature. The influence from waste composition data on the LCA results was quantified with a step-wise Global Sensitivity Analysis (GSA) approach involving contribution, sensitivity, uncertainty and discernibility analyses. The waste composition data contributed significantly to the LCA results and the uncertainty associated with these results. The importance of 405 individual waste properties was evaluated in comparison with 345 technology parameters. Overall, less than 10 physico-chemical properties dominated the output uncertainty of the LCA results, although these properties had low sensitivity in the model. Moreover, the uncertainties associated with the physico-chemical properties were responsible for output uncertainties that spanned from impacts to benefits. The GSA approach applied in this study constitutes a valuable tool for systematically assessing the importance of waste composition and for consciously collecting and using waste composition data within LCAs of waste management systems.

General information
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Authors: Bisinella, V. (Intern), Götze, R. (Intern), Conradsen, K. (Intern), Damgaard, A. (Intern), Christensen, T. H. (Intern), Astrup, T. F. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.661 SNIP 2.477 CiteScore 4.6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.644 SNIP 2.581 CiteScore 4.47
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.706 SNIP 2.328 CiteScore 4.07
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.461 SNIP 1.825 CiteScore 3.19
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Scopus rating (2010): SJR 1.419 SNIP 1.742
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Scopus rating (2009): SJR 0.942 SNIP 1.544
Improving SAR Automatic Target Recognition Models with Transfer Learning from Simulated Data

Data-driven classification algorithms have proved to do well for automatic target recognition (ATR) in synthetic aperture radar (SAR) data. Collecting data sets suitable for these algorithms is a challenge in itself as it is difficult and expensive. Due to the lack of labeled data sets with real SAR images of sufficient size, simulated data play a big role in SAR ATR development, but the transferability of knowledge learned on simulated data to real data remains to be studied further. In this letter, we show the first study of Transfer Learning between a simulated data set and a set of real SAR images. The simulated data set is obtained by adding a simulated object radar reflectivity to a terrain model of individual point scatters, prior to focusing. Our results show that a Convolutional Neural Network (Convnet) pretrained on simulated data has a great advantage over a Convnet trained only on real data, especially when real data are sparse. The advantages of pretraining the models on simulated data show both in terms of faster convergence during the training phase and on the end accuracy when benchmarked on the Moving and Stationary Target Acquisition and Recognition data set. These results encourage SAR ATR development to continue the improvement of simulated data sets of greater size and complex scenarios in order to build robust algorithms for real life SAR ATR applications.
The aim of this paper is to characterise the fibre orientation in unidirectional fibre reinforced polymers, namely glass and carbon fibre composites. The compression strength of the composite is related to the orientation of the fibres. Thus the orientation is essential when designing materials for wind turbine blades. The calculation of the fibre orientation distribution is based on segmenting the individual fibres from volumes that have been acquired through X-ray tomography. The segmentation method presented in this study can accurately extract individual fibres from low contrast X-ray scans of composites with high fibre volume fraction. From the individual fibre orientations, it is possible to obtain results which are independent of the scanning quality. The compression strength for both composites is estimated from the average fibre orientations and is found to be of the same order of magnitude as the measured values.

Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Wind Energy, Composites and Materials Mechanics
Authors: Emerson, M. J. (Intern), Jespersen, K. M. (Intern), Dahl, A. B. (Intern), Conradsen, K. (Intern), Mikkelsen, L. P. (Intern)
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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.53 SNIP 2.18 CiteScore 4.09
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.67 SNIP 2.538 CiteScore 4.08
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Scopus rating (2013): SJR 1.59 SNIP 2.828 CiteScore 3.92
ISI indexed (2013): ISI indexed yes
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Scopus rating (2011): SJR 1.443 SNIP 2.499 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.553 SNIP 2.241
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.536 SNIP 1.976
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Scopus rating (2008): SJR 1.388 SNIP 1.853
Scopus rating (2007): SJR 1.222 SNIP 2.188
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.208 SNIP 2.268
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Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.159 SNIP 1.671
Scopus rating (2003): SJR 1.132 SNIP 1.411
Scopus rating (2002): SJR 1.308 SNIP 1.512
Scopus rating (2001): SJR 1.426 SNIP 1.33
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Relations
Projects:
Individual fibre segmentation from 3D X-ray computed tomography for characterising the fibre orientation in unidirectional composite materials
In-line 3D print failure detection using computer vision

Here we present our findings on a novel real-time vision system that allows for automatic detection of failure conditions that are considered outside of nominal operation. These failure modes include warping, build plate delamination and extrusion failure. Our system consists of a calibrated camera whose position and orientation is known in the machine coordinate system. We simulate what the object under print should look like for any given moment in time. This is compared to a segmentation of the current print, and statistical detection of significant deviation. We demonstrate that this methodology precisely and unambiguously detects the time point of print failure.

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Integrating Multi-Purpose Natural Language Understanding, Robot's Memory, and Symbolic Planning for Task Execution in Humanoid Robots

We propose an approach for instructing a robot using natural language to solve complex tasks in a dynamic environment. In this study, we elaborate on a framework that allows a humanoid robot to understand natural language, derive symbolic representations of its sensorimotor experience, generate complex plans according to the current world state, and monitor plan execution. The presented development supports replacing missing objects and suggesting possible object locations. It is a realization of the concept of structural bootstrapping developed in the context of the European project Xperience. The framework is implemented within the robot development environment ArmarX. We evaluate the framework on the humanoid robot ARMAR-III in the context of two experiments: a demonstration of the real execution of a complex task in the kitchen environment on ARMAR-III and an experiment with untrained users in a simulation environment.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Innsbruck, Karlsruhe Institute of Technology KIT, University of Southern Denmark
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Interactive Stable Ray Tracing

Interactive ray tracing applications running on commodity hardware can suffer from objectionable temporal artifacts due to a low sample count. We introduce stable ray tracing, a technique that improves temporal stability without the over-blurring and ghosting artifacts typical of temporal post-processing filters. Our technique is based on sample reprojection and explicit hole filling, rather than relying on hole-filling heuristics that can compromise image quality. We make reprojection practical in an interactive ray tracing context through the use of a super-resolution bitmask to estimate screen space sample density. We show significantly improved temporal stability as compared with supersampling and an existing reprojection techniques. We also investigate the performance and image quality differences between our technique and temporal antialiasing, which typically incurs a significant amount of blur. Finally, we demonstrate the benefits of stable ray tracing by combining it with progressive path tracing of indirect illumination.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, NVIDIA
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Interpolation from Grid Lines: Linear, Transfinite and Weighted Method

When two sets of line scans are acquired orthogonal to each other, intensity values are known along the lines of a grid. To view these values as an image, intensities need to be interpolated at regularly spaced pixel positions. In this paper we evaluate three methods for interpolation from grid lines: linear, transfinite and weighted. Linear method does not preserve the known values along the grid lines. Transfinite method, known from mesh generation, preserves the known values but might cause overshoot. The weighted method, which we propose, is designed to combine the desired properties of transfinite method close to grid lines, and the stability of the linear method. We perform an extensive evaluation of the three interpolation methods across a range of upsampling rates for two data sets. Depending on the upsampling rate, we show significant difference in the performance of the three methods. We find that the transfinite interpolation works well for small upsampling rates and the proposed weighted interpolation method performs very well for all relevant upsampling rates.

Investigation of Tooling for Anisotropic Optical Functional Surfaces

This paper studied steel inserts with anisotropic surfaces for injection moulding. The inserts surfaces were machined by a five-axis micro-milling machine and the surface structures will be replicated by injection moulding. The aim of the surface structuring is to maximize visible contrast between horizontally orthogonal textured surfaces from a certain viewing angle, of both the insert and the polymer replicas. The contrast is defined by the difference of the reflectance between two areas with horizontally orthogonal textures under a certainly fixed light source. The brightness of the surface is assessed by processing the images obtained from a digital microscope Hirox RH-2000 [1]. Figure 1 illustrates the studied surface structure and the microscope. The optical axis of microscope can be tilted within 90 degrees from the horizontal level, which simulates the viewing angle; the analysed surface texture can be rotated horizontally by the adjusting the stage so only one surface was used to achieve orthogonal textures and images at different rotation angle can be captured. Via image processing tool, the reflectance (brightness of the obtained images) will be analysed and therefore the contrast can be calculated.
Maximum auto-mutual-information factor analysis

Based on the information theoretical measure mutual information derived from entropy and Kullback-Leibler divergence, an alternative to maximum autocorrelation factor analysis is sketched.

Medial structure generation for registration of anatomical structures

Medial structures (skeletons and medial manifolds) have shown capacity to describe shape in a compact way. In the field of medical imaging, they have been employed to enrich the description of organ anatomy, to improve segmentation, or to describe the organ position in relation to surrounding structures. Methods for generation of medial structures, however, are prone to the generation of medial artifacts (spurious branches) that traditionally need to be pruned before the medial structure can be used for further computations. The act of pruning can affect main sections of the medial surface, hindering its performance as shape descriptor. In this work, we present a method for the computation of medial structures that generates smooth medial surfaces that do not need to be explicitly pruned. Additionally, we present a validation framework for medial surface evaluation. Finally, we apply this method to create a parametric model of the cochlea shape that yields better registration results between cochleae.
Modeling Structural Brain Connectivity

The human brain consists of a gigantic complex network of interconnected neurons. Together all these connections determine who we are, how we react and how we interpret the world. Knowledge about how the brain is connected can further our understanding of the brain’s structural organization, help improve diagnosis, and potentially allow better treatment of a wide range of neurological disorders.

Tractography based on diffusion magnetic resonance imaging is a unique tool to estimate this “structural connectivity” of the brain non-invasively and in vivo. During the last decade, brain connectivity has increasingly been analyzed using graph theoretic measures adopted from network science and this characterization of the brain’s structural connectivity has been shown to be useful for the classification of populations, such as healthy and diseased subjects. The structural connectivity of the brain estimated using tractography is, however, derived by integrating noisy estimates of the local fiber orientation in each voxel, entailing biases and limitations in the estimated connections and resulting in noisy graphs.

In this thesis, the ability of stochastic block models to extract the latent organization of structural brain connectivity graphs is investigated. It is found that both the stochastic block model and its non-parametric extension, the infinite relational model, are able to reliably extract a clustering that better accounts for structural connectivity than cortical atlases based solely upon surface morphology. Furthermore, a statistical prediction framework to quantify the ability of a cortical parcellation to account for structural connectivity is proposed. It is tested on two commonly used cortical atlases that are both based on surface morphology, as well as on a recently proposed cortical parcellation by Glasser et al. (2016) that is based on both task and resting-state functional magnetic resonance imaging, cortical thickness and myelin. It is found that all three atlases capture the structural connectivity much better than random, but also that the parcellation based on multiple modalities is superior to those solely based on surface morphology.

The generation of structural brain connectivity graphs comprises a comprehensive processing pipeline, with various experimenter-defined parameters. The settings of these parameters are, however, unclear and this subjective aspect complicates the cross-comparison of studies investigating structural brain connectivity derived from tractography. Even though scan acquisition parameters, i.e. spatial resolution, angular resolution and b-value, are often discussed as possible factors influencing the final result, the impact of these factors on the derived structural connectivity graph has not yet been investigated. Herein, structural connectivity graphs, generated using different combinations of the three aforementioned acquisition parameters, are validated by comparison to a connectivity graph derived using invasive tracer injections in monkeys. It is found that the choice of acquisition parameters influences the derived structural connectivity graph and that higher angular resolution is always beneficial. Surprisingly, it is also found that higher spatial resolution does not improve the derived graph, but further investigation is needed to confirm this result.
Engineering of surface structure to obtain specific anisotropic reflectance properties has interesting applications in large scale production of plastic items. In recent work, surface structure has been engineered to obtain visible reflectance contrast when observing a surface before and after rotating it 90 degrees around its normal axis. We build an analytic anisotropic reflectance model based on the microstructure engineered to obtain such contrast. Using our model to render synthetic images, we predict the above mentioned contrasts and compare our predictions with the measurements reported in previous work. The benefit of an analytical model like the one we provide is its potential to be used in computer vision for estimating the quality of a surface sample. The quality of a sample is indicated by the resemblance of camera-based contrast measurements with contrasts predicted for an idealized surface structure. Our predictive model is also useful in optimization of the microstructure configuration, where the objective for example could be to maximize reflectance contrast.

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Men with type 2 diabetes mellitus (T2D) often have lowered testosterone levels and an increased risk of cardiovascular disease (CVD). Ectopic fat increases the risk of CVD, whereas subcutaneous gluteofemoral fat protects against CVD and has a beneficial adipokine-secreting profile. Testosterone replacement therapy (TRT) may reduce the content of ectopic fat and improve the adipokine profile in men with T2D. A randomized, double-blinded, placebo-controlled study in 39 men aged 50-70 years with T2D and bioavailable testosterone levels

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Southern Denmark, University of Novi Sad, Statens Serum Institut
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Volume segmentation is efficient for reconstructing material structure, which is important for several analyses, e.g., simulation with finite element method, measurement of quantitative information like surface area, surface curvature, volume, etc. We are concerned about the representations of the 3D volumes, which can be categorized into two groups: fixed voxel grids [1] and unstructured meshes [2]. Among these two representations, the voxel grids are more popular since manipulating a fixed grid is easier than an unstructured mesh, but they are less efficient for quantitative measurements. In many cases, the voxel grids are converted to explicit meshes, however the conversion may reduce the accuracy of the segmentations, and the effort for meshing is also not trivial. On the other side, methods using unstructured meshes have difficulty in handling topology changes. To reduce the complexity, previous methods only represent the
surfaces, thus they only segment a single region without exterior or interior information (e.g. holes). Finally, yet importantly, previous methods of both representations have issues with multi-material segmentation, where vacuum and overlapping between surfaces occur. This paper proposes a method for volume segmentation using a tetrahedral mesh. The compelling advantages of our method include: natural multi-material support; output is tetrahedral mesh that can be utilized for simulation and analysis directly; and the ability to control the resolution for compact meshes. We are also experimenting to prove our advantages on high accuracy; and the potentiality to accompany shape prior information during segmentation.

**General information**
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- **Organisations:** Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis
- **Authors:** Nguyen Trung, T. (Intern), Dahl, V. A. (Intern), Bærentzen, J. A. (Intern)
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**Multispectral UV imaging for determination of the tablet coating thickness**

The applicability of off-line multispectral ultraviolet (UV) imaging in combination with multivariate data analysis was investigated to determine the coating thickness and its distribution on the tablet surface during lab scale coating. The UV imaging results were compared with the weight gain measured for each individual tablet and the corresponding coating thickness and its distribution measured by terahertz pulsed imaging (TPI). Three different tablet formulations were investigated, two of which contained UV active tablet cores. Three coating formulations were applied: Aquacoat® ECD (a mainly translucent coating) and Eudragit® NE (a turbid coating containing solid particles). It was shown that UV imaging is a fast and non-destructive method to predict individual tablet weight gain as well as coating thickness. The coating thickness distribution profiles determined by UV imaging correlated to the results of the TPI measurements. UV imaging appears to hold a significant potential as a PAT tool for determination of the tablet coating thickness and its distribution resulting from its high measurement speed, high molar absorptivity and a high scattering coefficient, in addition to relatively low costs.

**General information**
- **State:** Published
- **Organisations:** Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Hamburg, University of Cambridge, University of Copenhagen
- **Authors:** Novikova, A. (Ekstern), Carstensen, J. M. (Intern), Zeitler, J. A. (Ekstern), Rades, T. (Ekstern), Leopold, C. S. (Ekstern)
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  - BFI (2015): BFI-level 1
  - Scopus rating (2015): SJR 0.969 SNIP 1.088 CiteScore 2.84
  - BFI (2014): BFI-level 1
  - Scopus rating (2014): SJR 0.994 SNIP 1.15 CiteScore 3.01
  - BFI (2013): BFI-level 1
Multispectral x-ray CT: multivariate statistical analysis for efficient reconstruction

Recent developments in multispectral X-ray detectors allow for an efficient identification of materials based on their chemical composition. This has a range of applications including security inspection, which is our motivation. In this paper, we analyze data from a tomographic setup employing the MultiX detector, that records projection data in 128 energy bins covering the range from 20 to 160 keV. Obtaining all information from this data requires reconstructing 128 tomograms, which is computationally expensive. Instead, we propose to reduce the dimensionality of projection data prior to reconstruction and reconstruct from the reduced data. We analyze three linear methods for dimensionality reduction using a dataset with 37 equally-spaced projection angles. Four bottles with different materials are recorded for which we are able to obtain similar discrimination of their content using a very reduced subset of tomograms compared to the 128 tomograms that would otherwise be needed without dimensionality reduction.

General information

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New approach for validating the segmentation of 3D data applied to individual fibre extraction

We present two approaches for validating the segmentation of 3D data. The first approach consists on comparing the amount of estimated material to a value provided by the manufacturer. The second approach consists on comparing the segmented results to those obtained from imaging modalities that provide a better resolution and therefore a more accurate segmentation. The imaging modalities used for comparison are scanning electron microscopy, optical microscopy and synchrotron CT. The validation methods are applied to assess the segmentation of individual fibres from X-ray microtomograms.

Photogrammetry for Repositioning in Additive Manufacturing

In this preliminary work, we present our current status on how to use single camera photogrammetry to determine the orientation of an additively manufactured partly finished object that has been repositioned in the printing chamber, from a single image taken with a calibrated camera, and comparing this to the CAD model of the object. We describe how this knowledge can be used to update the machine code of the printer such that printing of the object can be resumed in the new location. This opens possibilities for embedding and assembling foreign parts into the additively manufacturing pipeline, adding another layer of flexibility to the process. However, due to various error sources in estimating the orientation of the object, more work is needed before this update can be applied.
PicPrint: Embedding pictures in additive manufacturing
Here we present PicPrint, a method and tool for producing an additively manufactured lithophane, enabling transferring and embedding 2D information into additively manufactured 3D objects. The method takes an input image and converts it to a corresponding height-map, indicating the material density required to achieve a brightness specified at any given location. Non-linear scattering properties are compensated for using predefined falloff profiles. Using the produced height-map, a watertight mesh is distorted to match the specified material densities, after which the mesh is ready for either direct print on an additive manufacturing system, or transfer to other geometries via Boolean mesh operations.

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Source: PublicationPreSubmission
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Prediction of Motion Induced Image Degradation Using a Markerless Motion Tracker
In this work a markerless motion tracker, TCL2, is used to predict image quality in 3D T1 weighted MPRAGE MRI brain scans. An experienced radiologist scored the image quality for 172 scans as being usable or not usable, i.e. if a repeated scan was required. Based on five motion parameters, a classification algorithm was trained and an accuracy for identifying not usable images of 95.9% was obtained with a sensitivity of 91.7% and specificity of 96.3%. This work shows the feasibility of the markerless motion tracker for predicting image quality with a high accuracy.

General information
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Prediction of pork quality parameters by applying fractals and data mining on MRI
This work firstly investigates the use of MRI, fractal algorithms and data mining techniques to determine pork quality parameters non-destructively. The main objective was to evaluate the capability of fractal algorithms (Classical Fractal algorithm, CFA; Fractal Texture Algorithm, FTA and One Point Fractal Texture Algorithm, OPFTA) to analyse MRI in order to predict quality parameters of loin. In addition, the effect of the sequence acquisition of MRI (Gradient echo, GE; Spin echo, SE and Turbo 3D, T3D) and the predictive technique of data mining (Isotonic regression, IR and Multiple linear regression, MLR) were analysed. Both fractal algorithm, FTA and OPFTA are appropriate to analyse MRI of loins. The sequence acquisition, the fractal algorithm and the data mining technique seems to influence on the prediction results. For most physico-chemical parameters, prediction equations with moderate to excellent correlation coefficients were achieved by using the following combinations of acquisition sequences of MRI, fractal algorithms and data mining techniques: SE-FTA-MLR, SE-OPFTA-IR, GE-OPFTA-MLR, SE-OPFTA-MLR, with the last one offering the best prediction results. Thus, SE-OPFTA-MLR could be proposed as an alternative technique to determine physico-chemical traits of fresh and dry-cured loins in a non-destructive way with high accuracy.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, University of Extremadura, University of Copenhagen
Process chain for fabrication of anisotropic optical functional surfaces on polymer components

This paper aims to introduce a process chain for fabrication of anisotropic optical functional surfaces on polymer products. These surfaces under investigation are composed of micro serrated ridges. The scope was to maximize the visible contrast between horizontally orthogonal textured surfaces from a certain viewing angle. The process chain comprised three steps: tooling, replication, and quality assurance. Tooling was achieved by precision micro milling. Replication processes such as injection moulding, hot embossing, blow moulding, etc. were employed according to the specific type of product. In order to implement the traceability of the manufacturing process, the geometry and dimension of the micro structure on the tool and the replica were assessed via metrological methods. The functionality of the anisotropic surfaces on the polymer replicas were evaluated by a gonioreflectometer and image processing. Eventually, according to the function evaluation of polymer products, the process chain steps will be optimized by tuning the tooling and moulding processes.

Quantitative evaluation of peptide analogue distribution in mouse tissue using 3D computer modelling

The use of automated image analysis of microscopy images is increasing to enable high throughput approaches and unbiased analysis of the increasingly large data sets produced. This thesis investigates the use of automated image analysis to quantify peptide analogue distribution in mouse brain tissue. The main group of peptides included in this work was glucagon-like peptide 1 receptors agonists (GLP-1RA) used for treatment in diabetes and obesity. Two main image modalities have been applied for image acquisition; Light Sheet Fluorescence Microscopy (LSFM), and slide scanner images of 2D histology sections. The work demonstrates the use of automated image analysis based on image registration to quantify LSFM data of the peptide brain distribution following peripheral administration. The methodology was expanded during the PhD work to also include study of receptor mapping and brain activation. The automated analysis was enabled by integration with a digital multimodality brain atlas from the Allen Institute of Brain Science (AIBS). The work showed that GLP-1RAs accessed multiple brain regions mainly in the hypothalamus and hindbrain and led to increased brain activation in regions related to decreased food intake. The developed integrated brain atlas provides a novel analysis approach for LSFM data to aid researchers understand the complex brain biology related to development of pharmaceuticals with brain mode of action.
Optic disc drusen (ODD) are found in up to 2.4% of the population and are known to cause visual field defects. The purpose of the current study was to investigate how quantitatively estimated volume and anatomic location of ODD influence optic nerve function. Anatomic location, volume of ODD, and peripapillary retinal nerve fiber layer and macular ganglion cell layer thickness were assessed in 37 ODD patients using enhanced depth imaging optical coherence tomography. Volume of ODD was calculated by manual segmentation of ODD in 97 B-scans per eye. Anatomic characteristics were compared with optic nerve function using automated perimetric mean deviation (MD) and multifocal visual evoked potentials. Increased age (P = 0.015); larger ODD volume (P = 0.002); and more superficial anatomic ODD location (P = 0.007) were found in patients with ODD visible by ophthalmoscopy compared to patients with buried ODD. In a multivariate analysis, a worsening of MD was significantly associated with larger ODD volume (P <0.0001). No association was found between MD and weighted anatomic location, age, and visibility by ophthalmoscopy. Decreased ganglion cell layer thickness was significantly associated with worse MD (P = 0.025) and had a higher effect on MD when compared to retinal nerve fiber layer thickness. Large ODD volume is associated with optic nerve dysfunction. The worse visual field defects associated with visible ODD should only be ascribed to larger ODD volume and not to a more superficial anatomic ODD location.
Random walks with statistical shape prior for cochlea and inner ear segmentation in micro-CT images

A cochlear implant is an electronic device which can restore sound to completely or partially deaf patients. For surgical planning, a patient-specific model of the inner ear must be built using high-resolution images accurately segmented. We propose a new framework for segmentation of micro-CT cochlear images using random walks, where a region term estimated by a Gaussian mixture model is combined with a shape prior initially obtained by a statistical shape model (SSM). The region term can then take advantage of the high contrast between the background and foreground, while the shape prior guides the segmentation to the exterior of the cochlea and to less contrasted regions inside the cochlea. The prior is obtained via a non-rigid registration regularized by a statistical shape model. The SSM constrains the inner parts of the cochlea and ensures valid output shapes of the inner ear.

General information
State: Published
Authors: Ruiz Pujadas, E. (Ekstern), Piella, G. (Ekstern), Kjer, H. M. (Intern), González Ballester, M. A. (Ekstern)
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Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
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Real Time MRI Motion Correction with Markerless Tracking

Prospective motion correction for MRI neuroimaging has been demonstrated using MR navigators and external tracking systems using markers. The drawbacks of these two motion estimation methods include prolonged scan time plus lack of compatibility with all image acquisitions, and difficulties validating marker attachment resulting in uncertain estimation of the brain motion respectively. We have developed a markerless tracking system, and in this work we demonstrate the use of our system for prospective motion correction, and show that despite being computationally demanding, markerless tracking can be implemented for real time motion correction.
Scalable group level probabilistic sparse factor analysis
Many data-driven approaches exist to extract neural representations of functional magnetic resonance imaging (fMRI) data, but most of them lack a proper probabilistic formulation. We propose a scalable group level probabilistic sparse factor analysis (psFA) allowing spatially sparse maps, component pruning using automatic relevance determination (ARD) and subject specific heteroscedastic spatial noise modeling. For task-based and resting state fMRI, we show that the sparsity constraint gives rise to components similar to those obtained by group independent component analysis. The noise modeling shows that noise is reduced in areas typically associated with activation by the experimental design. The psFA model identifies sparse components and the probabilistic setting provides a natural way to handle parameter uncertainties. The variational Bayesian framework easily extends to more complex noise models than the presently considered.
Sensation of movement: An introduction

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Grünbaum, T. (Ekstern), Christensen, M. S. (Intern)
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Sense of moving: Moving closer to the movement

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Christensen, M. S. (Intern), Grünbaum, T. (Forskerdatabase)
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Short parietal lobe connections of the human and monkey brain

The parietal lobe has a unique place in the human brain. Anatomically, it is at the crossroad between the frontal, occipital, and temporal lobes, thus providing a middle ground for multimodal sensory integration. Functionally, it supports higher cognitive functions that are characteristic of the human species, such as mathematical cognition, semantic and pragmatic aspects of language, and abstract thinking. Despite its importance, a comprehensive comparison of human and simian intraparietal networks is missing. In this study, we used diffusion imaging tractography to reconstruct the major intralobar parietal tracts in twenty-one datasets acquired in vivo from healthy human subjects and eleven ex vivo datasets from five vervet and six macaque monkeys. Three regions of interest (postcentral gyrus, superior parietal lobule and inferior parietal lobule) were used to identify the tracts. Surface projections were reconstructed for both species and results compared to identify similarities or differences in tract anatomy (i.e., trajectories and cortical projections). In addition, post-mortem dissections were performed in a human brain. The largest tract identified in both human and monkey brains is a vertical pathway between the superior and inferior parietal lobules. This tract can be divided into an anterior (supramarginal gyrus) and a posterior (angular gyrus) component in both humans and monkey brains. The second prominent intraparietal tract connects the postcentral gyrus to both supramarginal and angular gyri of the inferior parietal lobule in humans but only to the supramarginal gyrus in the monkey brain. The third tract connects the postcentral gyrus to the anterior region of the superior parietal lobule and is more prominent in monkeys compared to humans. Finally, short U-shaped fibres in the medial and lateral aspects of the parietal lobe were identified in both species. A tract connecting the medial parietal cortex to the lateral inferior parietal cortex was observed in the monkey brain only. Our findings suggest a consistent pattern of intralobar parietal connections between humans and monkeys with some differences for those areas that have cytoarchitectonically distinct features in humans. The overall pattern of intraparietal connectivity supports the special role of the inferior parietal lobule in cognitive functions characteristic of humans.

General information

State: Accepted/In press
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, King's College London, SDN - Istituto di Ricerca Diagnostica e Nucleare, University of Oxford, Psychiatric Center Copenhagen, Rigshospitalet, Universite de Montreal
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Site Monitoring with Synthetic Aperture Radar Satellite Imagery

Based on a statistical test for the equality of polarimetric matrices following the complex Wishart distribution and a factorization of the test statistic, change analysis in a time series of multi-look polarimetric SAR data in variance-covariance or polarimetric matrix representation is carried out. The test statistic and its factorization detect if and when change(s) occur. This paper provides a short explanation of the method, describes available software, and gives examples of potential applications for site monitoring.
Spatial noise-aware temperature retrieval from infrared sounder data
In this paper we present a combined strategy for the retrieval of atmospheric profiles from infrared sounders. The approach considers the spatial information and a noise-dependent dimensionality reduction approach. The extracted features are fed into a canonical linear regression. We compare Principal Component Analysis (PCA) and Minimum Noise Fraction (MNF) for dimensionality reduction, and study the compactness and information content of the extracted features. Assessment of the results is done on a big dataset covering many spatial and temporal situations. PCA is widely used for these purposes but our analysis shows that one can gain significant improvements of the error rates when using MNF instead. In our analysis we also investigate the relationship between error rate improvements when including more spectral and spatial components in the regression model, aiming to uncover the trade-off between model complexity and error rates.

State estimation of the performance of gravity tables using multispectral image analysis
Gravity tables are important machinery that separate dense (healthy) grains from lighter (low yielding varieties) aiding in improving the overall quality of seed and grain processing. This paper aims at evaluating the operating states of such tables, which is a critical criterion required for the design and automation of the next generation of gravity separators. We present a method capable of detecting differences in grain densities, that as an elementary step forms the basis for a related optimization of gravity tables. The method is based on a multispectral imaging technology, capable of capturing differences in the surface chemistry of the kernels. The relevant micro-properties of the grains are estimated using a Canonical Discriminant Analysis (CDA) that segments the captured grains into individual kernels and we show that for wheat, our method correlates well with control measurements (R2 =0.93).
General information
State: Published
Authors: Hansen, M. A. E. (Ekstern), Kannan, A. S. (Ekstern), Lund, J. (Ekstern), Thorn, P. (Ekstern), Sasic, S. (Ekstern), Carstensen, J. M. (Intern)
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Statistical Image Analysis of Tomograms with Application to Fibre Geometry Characterisation
The goal of this thesis is to develop statistical image analysis tools to characterise the micro-structure of complex materials used in energy technologies, with a strong focus on fibre composites. These quantification tools are based on extracting geometrical parameters defining structures from 2D and 3D images, especially acquired through X-ray computed tomography (CT). Fibre composites are extensively used in transportation and energy technologies such as wind turbines. It is of high importance to characterise composites accurately and to understand their behaviour under load to ensure efficiency and longevity of these technologies.

Imaging with X-ray CT has been the foundation of the thesis. This enables analysis in 3D and at the micro-scale, where individual fibres are distinguishable. Additionally, ultra-fast X-ray CT and in-situ loading environments are able to image these composites with high resolution both in space and time to observe fast micro-structural changes.

This thesis demonstrates that statistical image analysis combined with X-ray CT opens up numerous possibilities for understanding the behaviour of fibre composites under real life conditions. Besides enabling characterisation of material properties, estimating individual fibre centre lines and diameters allows for quantification of small micro-structural changes with a high degree of accuracy, as it is possible to follow how each individual fibre changes across data-sets acquired under progressive loading conditions. Finally, the thesis demonstrates the precision to which fibre geometry can be characterised through X-ray CT and the developed data analysis tools.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Emerson, M. J. (Intern), Dahl, A. B. (Intern), Conradsen, K. (Intern)
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Thalamocortical Connectivity and Microstructural Changes in Congenital and Late Blindness

There is ample evidence that the occipital cortex of congenitally blind individuals processes nonvisual information. It remains a debate whether the cross-modal activation of the occipital cortex is mediated through the modulation of preexisting corticocortical projections or the reorganisation of thalamocortical connectivity. Current knowledge on this topic largely stems from anatomical studies in animal models. The aim of this study was to test whether purported changes in thalamocortical connectivity in blindness can be revealed by tractography based on diffusion-weighted magnetic resonance imaging. To assess the thalamocortical network, we used a clustering method based on the thalamic white matter projections towards predefined cortical regions. Five thalamic clusters were obtained in each group representing their cortical projections. Although we did not find differences in the thalamocortical network between congenitally blind individuals, late blind individuals, and normal sighted controls, diffusion tensor imaging (DTI) indices revealed significant microstructural changes within thalamic clusters of both blind groups. Furthermore, we find a significant decrease in fractional anisotropy (FA) in occipital and temporal thalamocortical projections in both blind groups that were not captured at the network level. This suggests that plastic microstructural changes have taken place, but not in a degree to be reflected in the tractography-based thalamocortical network.

General information
State: Published
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Scopus rating (2016): SJR 1.502 SNIP 0.871 CiteScore 3.21
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Scopus rating (2015): SJR 1.867 SNIP 1.1 CiteScore 3.47
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Scopus rating (2014): SJR 2.018 SNIP 0.908 CiteScore 3.35
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.014 SNIP 0.752 CiteScore 3.24
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Scopus rating (2012): SJR 1.804 SNIP 0.651 CiteScore 2.82
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Scopus rating (2009): SJR 2.109 SNIP 1.075
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.024 SNIP 0.962
Scopus rating (2007): SJR 0.68 SNIP 1.019
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Scopus rating (2005): SJR 0.662 SNIP 0.416
The challenge of mapping the human connectome based on diffusion tractography

Tractography based on non-invasive diffusion imaging is central to the study of human brain connectivity. To date, the approach has not been systematically validated in ground truth studies. Based on a simulated human brain data set with ground truth tracts, we organized an open international tractography challenge, which resulted in 96 distinct submissions from 20 research groups. Here, we report the encouraging finding that most state-of-the-art algorithms produce tractograms containing 90% of the ground truth bundles (to at least some extent). However, the same tractograms contain many more invalid than valid bundles, and half of these invalid bundles occur systematically across research groups.

Taken together, our results demonstrate and confirm fundamental ambiguities inherent in tract reconstruction based on orientation information alone, which need to be considered when interpreting tractography and connectivity results. Our approach provides a novel framework for estimating reliability of tractography and encourages innovation to address its current limitations.

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Web of Science (2017): Indexed yes
The Crossed Projection to the Striatum in Two Species of Monkey and in Humans: Behavioral and Evolutionary Significance

The corpus callosum establishes the anatomical continuity between the 2 hemispheres and coordinates their activity. Using histological tracing, single axon reconstructions, and diffusion tractography, we describe a callosal projection to n caudatus and putamen in monkeys and humans. In both species, the origin of this projection is more restricted than that of the ipsilateral projection. In monkeys, it consists of thin axons (0.4–0.6 µm), appropriate for spatial and temporal dispersion of subliminal inputs. For prefrontal cortex, contralateral minus ipsilateral delays to striatum calculated from axon diameters and conduction distance are <2 ms in the monkey and, by extrapolation, <4 ms in humans. This delay corresponds to the performance in Poffenberger's paradigm, a classical attempt to estimate central conduction delays, with a neuropsychological task. In both species, callosal cortico-striatal projections originate from prefrontal, premotor, and motor areas. In humans, we discovered a new projection originating from superior parietal lobule, supramarginal, and superior temporal gyrus, regions engaged in language processing. This projection crosses in the isthmus the lesion of which was reported to dissociate syntax and prosody. The projection might originate from an overproduction of callosal projections in development, differentially pruned depending on species.
The impact of tool wear on the functionality of replicated polymer surface with micro structures

Wear happened frequently in the tooling process of mold for polymer production. The scope of this paper is to understand how the wear of the milling tool affected the function of the replicated polymer surface. This study is part of the process chain of fabrication of optical functional surfaces on polymer components. The aiming function of the surfaces is to maximize the reflectance from a certain viewing angle and direction, and minimize from its horizontally orthogonal position, i.e. to maximize the contrast between two horizontally orthogonal view positions at the same inclination. A five-axis micro milling machine was employed to pattern the surface of a steel insert for subsequent polymer replication.

In order to conduct the study, 1200 pixels (0.8 x 0.8 mm²) was machined on the surface of a steel insert using the same mill tool (Ø 0.5 mm, ARNO®); each of the pixels contains 16 ridges which is illustrated in figure 1 (a). The obtained surface structures were replicated using liquid silicon rubber (LSR).

The mill tool was inspected by scanning electron microscope (SEM) before and after the machining. Noticeable wear was observed. The weight of the studied tool was measured before and after machining for comparison. The obtained surface features on the insert and the LSR replica were measured using a confocal 3D laser scanner. The reflectance of the surfaces on the LSR replica was evaluated using a gonioreflectometer[1]. The gonioreflectometer captured the images of every 100th pixel from all the viewing angles by rotating the sample holder and tilting the objective lens. The reflectance for each configuration were obtained via image processing tools.

Results in this study include: 1. Tool wear was visualized by SEM images, which is shown in figure 1 (b). 2. However, the weight decrease could not be detected due to lack of precision in the measurement. 3. The number of defects on the obtained surface structures increased significantly along with the process. 4. The reflectance of these pixels on the LSR replica decreased from the first machined one to the last one.

As a conclusion, the tool (Ø 0.5mm, ARNO®) used in this study worn after machining for approximately 100 pixels, considering the function loss of replica surface. Future work will be dedicated to the methods that can prolong the tool life.

General information
State: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
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Threat detection of liquid explosives and precursors from their x-ray scattering pattern using energy dispersive detector technology

Energy dispersive X-ray diffraction (EDXRD) can be applied for identification of liquid threats in luggage scanning in security applications. To define the instrumental design, the framework for data reduction and analysis and test the performance of the threat detection in various scenarios, a flexible laboratory EDXRD test setup was build. A data set of overall 570 EDXRD spectra has been acquired for training and testing of threat identification algorithms. The EDXRD data was acquired with limited count statistics and at multiple detector angles and merged after correction and normalization. Initial testing of the threat detection algorithms with this data set indicate the feasibility of detection levels of > 95 % true positive with < 6 % false positive alarms.

General information
State: Published
Organisations: Department of Physics, Neutrons and X-rays for Materials Physics, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
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Number of pages: 9
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Journal: Proceedings of SPIE - International Society for Optical Engineering
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To be active through indoor-climbing: an exploratory feasibility study in a group of children with cerebral palsy and typically developing children

Background: Cerebral Palsy (CP) is the most common cause of motor disabilities in children and young adults and it is also often associated with cognitive and physiological challenges. Climbing requires a multifaceted repertoire of movements, participants at all levels of expertise may be challenged functionally and cognitively, making climbing of great potential interest in (re)habilitation settings. However, until now only few research projects have investigated the feasibility of climbing as a potential activity for heightening physical activity in children with CP and the possible beneficial effects of climbing activities in populations with functional and/or cognitive challenges. The aim of this study was therefore to test the feasibility of an intensive 3 weeks indoor-climbing training program in children with CP and typically developing (TD) peers. In addition we evaluated possible functional and cognitive benefits of 3 weeks of intensive climbing training in 11 children with cerebral palsy (CP) aged 11-13 years and six of their TD peers.

Method: The study was designed as a feasibility and interventional study. We evaluated the amount of time spent being physically active during the 9 indoor-climbing training sessions, and climbing abilities were measured. The participants were tested in a series of physiological, psychological and cognitive tests: two times prior to and one time following the training in order to explore possible effects of the intervention.

Results: The children accomplished the training goal of a total of nine sessions within the 3-week training period. The time of physical activity during a 2:30 h climbing session, was comparably high in the group of children with CP and the TD children. The children with CP were physically active on average for almost 16 h in total during the 3 weeks. Both groups of participants improved their climbing abilities, the children with CP managed to climb a larger proportion of the tested climbing route at the end of training and the TD group climbed faster. For the children with CP this was accompanied by significant improvements in the Sit-to-stand test (p <0.01), increased rate of force development in the least affected hand during an explosive pinch test and increased muscular-muscular coherence during a pinch precision test (p <0.05). We found no improvements in maximal hand or finger strength and no changes in cognitive abilities or psychological well-being in any of the groups.

Conclusions: These findings show that it is possible to use climbing as means to make children with CP physically active. The improved motor abilities obtained through the training is likely reflected by increased synchronization between cortex and muscles, which results in a more efficient motor unit recruitment that may be transferred to daily functional abilities.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen, Elsass Institute
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Main Research Area: Technical/natural sciences
Towards Plug-n-Play robot guidance: Advanced 3D estimation and pose estimation in Robotic applications

Robots are a key technology in the quest for higher productivity in Denmark and Europe. Robots have existed in many years as a part of production lines where they have solved monotonous and repetitive task in mass production industries. Typical the programming of these robots are handled by engineers with special knowledge who have often raised the price for using robots to a given production task. If robots have to be applicable for small and medium sized enterprises where production task often changes and batch sizes are below 50 products it is necessary that the staff is capable of re-
programming the robot by themselves.

During the last five years a number of collaborative robots are introduced on the marked e.g. Universal Robot, which enables a production worker to program the robot to solve simple tasks. With the collaborative robot the production worker is able to make the robot grind, mill, weld and move objects, which are physical located at the same positions. In order to place objects in the same position each time, custom-made mechanical fixtures and aligners are constructed to ensure that objects are not moving. It is expensive to design and build these fixtures and it is difficult to quickly change to a novel task. In some cases where objects are placed in bins and boxes it is not possible to position the objects in the same location each time.

To avoid designing expensive mechanical solutions and to be able to pick objects from boxes and bins, a sensor is necessary to guide the robot. Today, primarily 2D vision systems are applied in industrial robotics, which are in-flexible and hard to program for the production workers. Smart cameras, which are easier to re-configure and program to detect objects exist. However, computing the correct position such that a robot can move to this position is still a challenge which requires calibration processes. Moreover, the ability to make the solution robust such that it is running 24/7 in a production is demanding and requires the right skills. Basically, the vision part of a flexible automation solution is difficult to manage for a production worker while the robot motion programming is easily handled with the new collaborative robots. This thesis deals with robot vision technologies and how these are made easier for production workers program in order to get robots to recognize and compute the position of objects in the industry.

This thesis investigates and discusses methods to encapsulate a 2D vision system into a framework in order to make changes in production task easier. The framework is presented in [Contribution B] and [Contribution C] and demonstrates how re-configuration of vision systems is made easier but in the same time reviles some of the fundamental problems that exist by observing a tree dimensional world through a two dimensional vision system. This requires a calibration procedure every time in order to convert 2D to 3D, which still is a cumbersome process for a production worker.

For this reason, the rest of the thesis investigates and discusses how 3D computer vision techniques can ease the problem of recognizing and computing the position of objects. In [Contribution D] a small lightweight 3D sensor is presented. The 3D sensor has a size that makes it suitable for tool mounting at a collaborative robot. It is based on structured light principles and 3D estimation techniques, which enables fast and accurate acquisition of point clouds of low textured and reflective industrial objects.

In [Contribution E] a 3D vision system for easy learning of 3D models is presented. The system creates a 3D model of the object by scanning it from three views. Then the object acts as a reference model in the system when new instances of the object have to be located in the scene. With this approach fast re-configuration is possible. In [Contribution F] a new dataset for 3D object recognition and an evaluation of state-of-the-art local features for object recognition are presented. The contribution shows as expected that state-of-the-art 3D object recognition algorithms are not good enough to locate industrial objects with few local shape features on the surface.
Unraveling fermentation data – a Novozymes case study

Industrial fermentation processes are monitored using a variety of sensors. Typically, measurements are taken throughout the entire production process. Production may be carried out under supervision of different operators (operator variation), on different sites (global variation), in different buildings and/or in different tanks (local variation). However, up to now processes are mainly controlled according to traditional recipes and experience.

User-friendly simultaneous tomographic reconstruction and segmentation with class priors

Simultaneous Reconstruction and Segmentation (SRS) strategies for computed tomography (CT) present a way to combine the two tasks, which in many applications traditionally are performed as two successive and separate steps. A combined model has a potentially positive effect by allowing the two tasks to influence one another, at the expense of a more complicated algorithm. The combined model increases in complexity due to additional parameters and settings requiring tuning, thus complicating the practical usability. This paper takes its outset in a recently published variational algorithm for SRS. We propose a simplification that reduces the number of required parameters, and we perform numerical experiments investigating the effect and the conditions under which this approach is feasible.

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UV imaging of Multiple Unit Pellet System (MUPS) tablets: A case study of acetylsalicylic acid stability

The applicability of multispectral ultraviolet (UV) imaging in combination with multivariate image analysis was investigated to monitor API degradation within multiple unit pellet system (MUPS) tablets during storage. For this purpose, acetylsalicylic acid (ASA) layered pellets were coated with Eudragit® RL PO and compressed to MUPS tablets. These tablets were stored under four different conditions with different levels of relative humidity (0 and 75%) and temperature (21 and 40 °C) and analysed at seven storage time points (0, 15, 40, 140, 165, 265, and 330 d). The UV imaging results for estimation of the salicylic acid (SA) concentration as degradation product of ASA in the tablets were compared to the SA concentration measured by high performance liquid chromatography with a partial least squares regression resulting in an RMSEP of 4.86% and an R² of 0.9812. The estimation of the SA concentration based on mean UV reflectance spectra was possible even through the coating of the API pellets and at low concentration levels. In addition, the distribution of the SA concentration on the tablet surfaces for different storage time periods was visualized. UV imaging as fast and non-destructive method appears to offer significant potential for monitoring of API degradation during stability studies.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Hamburg, University of Copenhagen
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Scopus rating (2016): CiteScore 4.49 SJR 1.366 SNIP 1.409
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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.414 SNIP 1.496 CiteScore 4.37
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.469 SNIP 1.586 CiteScore 4.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.558 SNIP 1.706 CiteScore 4.64
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.976 SNIP 1.933 CiteScore 5.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
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Virtual reality inspection and painting with measured BRDFs

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Dal Corso, A. (Intern), Stets, J. D. (Intern), Luongo, A. (Intern), Nielsen, J. B. (Intern), Frisvad, J. R. (Intern), Aanæs, H. (Intern)
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Visualization and labeling of point clouds in virtual reality
We present a Virtual Reality (VR) application for labeling and handling point cloud data sets. A series of room-scale point clouds are recorded as a video sequence using a Microsoft Kinect. The data can be played and paused, and frames can be skipped just like in a video player. The user can walk around and inspect the data while it is playing or paused. Using the tracked hand-held controller, the user can select and label individual parts of the point cloud. The points are highlighted with a color when they are labeled. With a tracking algorithm, the labeled points can be tracked from frame to frame to ease the labeling process. Our sample data is an RGB point cloud recording of two people juggling with pins. Here, the user can select and label, for example, the juggler pins as shown in Figure 1. Each juggler pin is labeled with various colors to indicate different labels.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Massachusetts Institute of Technology
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Visualization of and Software for Omnibus Test Based Change Detected in a Time Series of Polarimetric SAR Data

Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution and a factorization of this test statistic with associated p-values, change analysis in a time series of multilook polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change occurs. Using airborne EMISAR and spaceborne RADARSAT-2 data this paper focuses on change detection based on the p-values, on visualization of change at pixel as well as segment level, and on computer software.

General Information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing, Research Center Jülich GmbH
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern), Canty, M. J. (Ekstern)
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Scopus rating (2007): SJR 0.797 SNIP 1.305
Wearable Gaze Trackers: Mapping Visual Attention in 3D

The study of visual attention in humans relates to a wide range of areas such as: psychology, cognition, usability, and marketing. These studies have been limited to fixed setups with respondents sitting in front of a monitor mounted with a gaze tracking device. The introduction of wearable mobile gaze trackers allows respondents to move freely in any real world 3D environment, removing the previous restrictions. In this paper we propose a novel approach for processing visual attention of respondents using mobile wearable gaze trackers in a 3D environment. The pipeline consists of 3 steps: modeling the 3D area-of-interest, positioning the gaze tracker in 3D space, and 3D mapping of visual attention. The approach is general, but as a case study we created 3D heat maps of respondents visiting supermarket shelves as well as finding their in-store movement relative to these shelves. The method allows for analysis across multiple respondents and to distinguish between phases of in-store orientation (far away) and product recognition/selection (up close) based on distance to shelves.

Active Appearance Segmentation for Intensity Inhomogeneity in Light Sheet Fluorescence Microscopy

Active Appearance Models (AAM) are used for annotating or segmenting shapes in biomedical images. Performance relies heavily on the image data used to train the AAM. In this paper we improve the generalization properties of the model by making it robust to slowly varying spatial intensity inhomogeneities which are often seen in Light Sheet Fluorescence Microscopy (LSFM) images. This robustness is achieved by modelling the appearance of an image as a regularized Normalized Gradient Field (rNGF). We perform two experiments to challenge the model. First it is tested using a repeated leave-one-out approach on images with minimal imperfections where the left out images are corrupted by a simulated bias field and segmented using the AAM. Secondly we test the model on LSFM images with common acquisition problems. In both experiments the proposed approach outperforms the often used AAM implementation based on Sum of Squared Differences.
A framework for geometry acquisition, 3-D printing, simulation, and measurement of head-related transfer functions with a focus on hearing-assistive devices

Individual head-related transfer functions (HRTFs) are essential in applications like fitting hearing-assistive devices (HADs) for providing accurate sound localization performance. Individual HRTFs are usually obtained through intricate acoustic measurements. This paper investigates the use of a three-dimensional (3D) head model for acquisition of individual HRTFs. Two aspects were investigated; whether a 3D-printed model can replace measurements on a human listener and whether numerical simulations can replace acoustic measurements. For this purpose, HRTFs were acoustically measured for four human listeners and for a 3D printed head model of one of these listeners. Further, HRTFs were simulated by applying the finite element method to the 3D head model. The monaural spectral features and spectral distortions were very similar between re-measurements and between human and printed measurements, however larger deviations were observed between measurement and simulation. The binaural cues were in agreement among all HRTFs of the same listener, indicating that the 3D model is able to provide localization cues potentially accessible to HAD users. Hence, the pipeline of geometry acquisition, printing, and acoustic measurements or simulations, seems to be a promising step forward towards in-silico design of HADs.
We present a fully automated generative method for simultaneous brain tumor and organs-at-risk segmentation in multi-modal magnetic resonance images. The method combines an existing whole-brain segmentation technique with a spatial tumor prior, which uses convolutional restricted Boltzmann machines to model tumor shape. The method is not tuned to any specific imaging protocol and can simultaneously segment the gross tumor volume, peritumoral edema and healthy tissue structures relevant for radiotherapy planning. We validate the method on a manually delineated clinical data set of glioblastoma patients by comparing segmentations of gross tumor volume, brainstem and hippocampus. The preliminary results demonstrate the feasibility of the method.

A generative model for segmentation of tumor and organs-at-risk for radiation therapy planning of glioblastoma patients

We present a fully automated generative method for simultaneous brain tumor and organs-at-risk segmentation in multi-modal magnetic resonance images. The method combines an existing whole-brain segmentation technique with a spatial tumor prior, which uses convolutional restricted Boltzmann machines to model tumor shape. The method is not tuned to any specific imaging protocol and can simultaneously segment the gross tumor volume, peritumoral edema and healthy tissue structures relevant for radiotherapy planning. We validate the method on a manually delineated clinical data set of glioblastoma patients by comparing segmentations of gross tumor volume, brainstem and hippocampus. The preliminary results demonstrate the feasibility of the method.
A Generative Probabilistic Model and Discriminative Extensions for Brain Lesion Segmentation - With Application to Tumor and Stroke

We introduce a generative probabilistic model for segmentation of brain lesions in multi-dimensional images that generalizes the EM segmenter, a common approach for modelling brain images using Gaussian mixtures and a probabilistic tissue atlas that employs expectation-maximization (EM), to estimate the label map for a new image. Our model augments the probabilistic atlas of the healthy tissues with a latent atlas of the lesion. We derive an estimation algorithm with closed-form EM update equations. The method extracts a latent atlas prior distribution and the lesion posterior distributions jointly from the image data. It delineates lesion areas individually in each channel, allowing for differences in lesion appearance across modalities, an important feature of many brain tumor imaging sequences. We also propose discriminative model extensions to map the output of the generative model to arbitrary labels with semantic and biological meaning, such as "tumor core" or "fluid-filled structure", but without a one-to-one correspondence to the hypo- or hyper-intense lesion areas identified by the generative model. We test the approach in two image sets: the publicly available BRATS set of glioma patient scans, and multimodal brain images of patients with acute and subacute ischemic stroke. We find the generative model that has been designed for tumor lesions to generalize well to stroke images, and the extended discriminative-discriminative model to be one of the top ranking methods in the BRATS evaluation.
Purpose: Identification of key inputs and their effect on results from Life Cycle Assessment (LCA) models is fundamental. Because parameter importance varies greatly between cases due to the interaction of sensitivity and uncertainty, these features should never be defined a priori. However, exhaustive parametrical uncertainty analyses may potentially be complicated and demanding, both with analytical and sampling methods. Therefore, we propose a systematic method for selection of critical parameters based on a simplified analytical formulation that unifies the concepts of sensitivity and uncertainty in a Global Sensitivity Analysis (GSA) framework.

Methods: The proposed analytical method based on the...
calculation of sensitivity coefficients (SC) is evaluated against Monte Carlo sampling on traditional uncertainty assessment procedures, both for individual parameters and for full parameter sets. Three full-scale waste management scenarios are modelled with the dedicated waste LCA model EASETECH and a full range of ILCD recommended impact categories. Common uncertainty ranges of 10% are used for all parameters, which we assume to be normally distributed. The applicability of the concepts of additivity of variances and GSA is tested on results from both uncertainty propagation methods. Then, we examine the differences in discernibility analyses results carried out with varying numbers of sampling points and parameters. Results and discussion: The proposed analytical method complies with the Monte Carlo results for all scenarios and impact categories, but offers substantially simpler mathematical formulation and shorter computation times. The coefficients of variation obtained with the analytical method and Monte Carlo differ only by 1%, indicating that the analytical method provides a reliable representation of uncertainties and allows determination of whether a discernibility analysis is required. The additivity of variances and the GSA approach show that the uncertainty in results is determined by a limited set of important parameters. The results of the discernibility analysis based on these critical parameters vary only by 1% from discernibility analyses based on the full set, but require significantly fewer Monte Carlo runs. Conclusions: The proposed method and GSA framework provide a fast and valuable approximation for uncertainty quantification. Uncertainty can be represented sparsely by contextually identifying important parameters in a systematic manner. The proposed method integrates with existing step-wise approaches for uncertainty analysis by introducing a global importance analysis before uncertainty propagation.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.581 SNIP 1.716 CiteScore 2.82
ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.447 SNIP 1.861
This paper presents a new large scale dataset targeting evaluation of local shape descriptors and 3d object recognition algorithms. The dataset consists of point clouds and triangulated meshes from 292 physical scenes taken from 11 different views; a total of approximately 3204 views. Each of the physical scenes contain 10 occluded objects resulting in a dataset with 32040 unique object poses and 45 different object models. The 45 object models are full 360 degree models which are scanned with a high precision structured light scanner and a turntable. All the included objects belong to different geometric groups; concave, convex, cylindrical and flat 3D object models. The object models have varying amount of local geometric features to challenge existing local shape feature descriptors in terms of descriptiveness and robustness. The dataset is validated in a benchmark which evaluates the matching performance of 7 different state-of-the-art local shape descriptors. Further, we validate the dataset in a 3D object recognition pipeline. Our benchmark shows as expected that local shape feature descriptors without any global point relation across the surface have a poor matching performance with flat and cylindrical objects. It is our objective that this dataset contributes to the future development of next generation of 3D object recognition algorithms. The dataset is public available at http://roboimagedata.compute.dtu.dk/.

A Large-Scale 3D Object Recognition dataset

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Danish Technological Institute, University of Southern Denmark
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An omnibus likelihood test statistic and its factorization for change detection in time series of polarimetric SAR data

Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a short sequence of multilook, polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change(s) occur. The technique is demonstrated on airborne EMISAR L-band data but may be applied to Sentinel-1, Cosmo-SkyMed, TerraSAR-X, ALOS and RadarSat-2 or other dual- and quad/full-pol, and even single-pol data also.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern)
Pages: 316-319
Publication date: 2016

A patch-based pseudo-CT approach for MRI-only radiotherapy in the pelvis

In radiotherapy based only on magnetic resonance imaging (MRI), knowledge about tissue electron densities must be derived from the MRI. This can be achieved by converting the MRI scan to the so-called pseudo-computed tomography (pCT). An obstacle is that the voxel intensities in conventional MRI scans are not uniquely related to electron density. The authors previously demonstrated that a patch-based method could produce accurate pCTs of the brain using conventional T₁-weighted MRI scans. The method was driven mainly by local patch similarities and relied on simple affine registrations between an atlas database of the co-registered MRI/CT scan pairs and the MRI scan to be converted. In this study, the authors investigate the applicability of the patch-based approach in the pelvis. This region is challenging for a method based on local similarities due to the greater inter-patient variation. The authors benchmark the method against a baseline pCT strategy where all voxels inside the body contour are assigned a water-equivalent bulk density. Furthermore, the authors implement a parallelized approximate patch search strategy to speed up the pCT generation time to a more clinically relevant level. The data consisted of CT and T₁-weighted MRI scans of 10 prostate patients. pCTs were generated using an approximate patch search algorithm in a leave-one-out fashion and compared with the CT using frequently described metrics such as the voxel-wise mean absolute error (MAE_vox) and the deviation in water-equivalent path lengths. Furthermore, the dosimetric accuracy was tested for a volumetric modulated arc therapy plan using dose–volume histogram (DVH) point deviations and γ-index analysis. The patch-based approach had an average MAE_vox of 54 HU; median deviations of less than 0.4% in relevant DVH points and a γ-index pass rate of 0.97 using a 1%/1 mm criterion. The patch-based approach showed a significantly better performance than the baseline water pCT in almost all metrics. The approximate patch search strategy was 70x faster than a brute-force search, with an average prediction time of 20.8 min. The authors showed that a patch-based method based on affine registrations and T₁-weighted MRI could generate accurate pCTs of the pelvis. The main source of differences between pCT and CT was positional changes of air pockets and body outline.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Andreasen, D. (Intern), Van Leemput, K. (Intern), Edmund, J. M. (Ekstern)
Number of pages: 11
A self-calibrating robot based upon a virtual machine model of parallel kinematics

A delta-type parallel kinematics system for Additive Manufacturing has been created, which through a probing system can recognise its geometrical deviations from nominal and compensate for these in the driving inverse kinematic model of the machine. Novelty is that this model is derived from a virtual machine of the kinematics system, built on principles from geometrical metrology. Relevant mathematically non-trivial deviations to the ideal machine are identified and decomposed into elemental deviations. From these deviations, a routine is added to a physical machine tool, which allows it to recognise its own geometry by probing the vertical offset from tool point to the machine table, at positions in the horizontal plane. After automatic calibration the positioning error of the machine tool was reduced from an initial error after its assembly of ±170 μm to a calibrated error of ±3 μm. Excelling by speed, the calibration was executed in less than 3 min.

Atomic Stretch: Optimally bounded real-time stretching and beyond

Atomic Stretch is a plugin for your preferred Adobe video editing tool, allowing real-time smooth and optimally bounded retarget-ting from and to any aspect ratio. The plugin allows preserving of high interest pixels through a protected region, attention redirection through color-modification, countering barrelling effects through vertical stretching, and tracking of targets of interest.
Autoencoding beyond pixels using a learned similarity metric
We present an autoencoder that leverages learned representations to better measure similarities in data space. By combining a variational autoencoder (VAE) with a generative adversarial network (GAN) we can use learned feature representations in the GAN discriminator as basis for the VAE reconstruction objective. Thereby, we replace element-wise errors with feature-wise errors to better capture the data distribution while offering invariance towards e.g. translation. We apply our method to images of faces and show that it outperforms VAEs with element-wise similarity measures in terms of visual fidelity. Moreover, we show that the method learns an embedding in which high-level abstract visual features (e.g. wearing glasses) can be modified using simple arithmetic.

Automatic measurement of orbital volume in unilateral coronal synostosis
Premature fusion of the coronal suture on one side of the calvaria (unilateral coronal synostosis, UCS) results in asymmetric craniofacial development and the deformation of the orbits. Often this necessitates surgery, where CT scanning is employed to obtain measures of the bony orbit. These measures are typically computed by guided procedures that require expert time. We propose a method with higher degree of automation based on finding an optimal smooth closed surface. CT scans of 17 infants with UCS are included in our experimental validation, where we compare our method to expert guided segmentations. We obtain similar measures, as well as high Dice scores, compared to the experts. The run time for the proposed approach with a prototype implementation is around 3 minutes on a standard laptop, making the method suitable for rapid evaluation of orbital volume in UCS.
Automatic Model Generation Framework for Computational Simulation of Cochlear Implantation

Recent developments in computational modeling of cochlear implantation are promising to study in silico the performance of the implant before surgery. However, creating a complete computational model of the patient's anatomy while including an external device geometry remains challenging. To address such a challenge, we propose an automatic framework for the generation of patient-specific meshes for finite element modeling of the implanted cochlea. First, a statistical shape model is constructed from high-resolution anatomical μCT images. Then, by fitting the statistical model to a patient's CT image, an accurate model of the patient-specific cochlea anatomy is obtained. An algorithm based on the parallel transport frame is employed to perform the virtual insertion of the cochlear implant. Our automatic framework also incorporates the surrounding bone and nerve fibers and assigns constitutive parameters to all components of the finite element model. This model can then be used to study in silico the effects of the electrical stimulation of the cochlear implant. Results are shown on a total of 25 models of patients. In all cases, a final mesh suitable for finite element simulations was obtained, in an average time of 94 s. The framework has proven to be fast and robust, and is promising for a detailed prognosis of the cochlear implantation surgery.
Bayesian longitudinal segmentation of hippocampal substructures in brain MRI using subject-specific atlases

The hippocampal formation is a complex, heterogeneous structure that consists of a number of distinct, interacting subregions. Atrophy of these subregions is implied in a variety of neurodegenerative diseases, most prominently in Alzheimer’s disease (AD). Thanks to the increasing resolution of MR images and computational atlases, automatic segmentation of hippocampal subregions is becoming feasible in MRI scans. Here we introduce a generative model for dedicated longitudinal segmentation that relies on subject-specific atlases. The segmentations of the scans at the different time points are jointly computed using Bayesian inference. All time points are treated the same to avoid processing bias.

We evaluate this approach using over 4700 scans from two publicly available datasets (ADNI and MIRIAD). In test–retest reliability experiments, the proposed method yielded significantly lower volume differences and significantly higher Dice overlaps than the cross-sectional approach for nearly every subregion (average across subregions: 4.5% vs. 6.5%, Dice overlap: 81.8% vs. 75.4%). The longitudinal algorithm also demonstrated increased sensitivity to group differences: in MIRIAD (69 subjects: 46 with AD and 23 controls), it found differences in atrophy rates between AD and controls that the cross sectional method could not detect in a number of subregions: right parasubiculum, left and right presubiculum, right subiculum, left dentate gyrus, left CA4, left HATA and right tail. In ADNI (836 subjects: 369 with AD, 215 with early cognitive impairment — eMCI — and 252 controls), all methods found significant differences between AD and controls, but the proposed longitudinal algorithm detected differences between controls and eMCI and differences between eMCI and AD that the cross sectional method could not find: left presubiculum, right subiculum, left and right parasubiculum, left and
right HATA. Moreover, many of the differences that the cross-sectional method already found were detected with higher significance. The presented algorithm will be made available as part of the open-source neuroimaging package FreeSurfer.

**General information**

**State:** Published  
**Organisations:** Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Basque Center on Cognition, Brain and Language, Harvard Medical School, University of Castilla–La Mancha  
**Authors:** Iglesias, J. E. (Ekstern), Van Leemput, K. (Intern), Augustinack, J. (Ekstern), Insausti, R. (Ekstern), Fischl, B. (Ekstern), Reuter, M. (Ekstern)  
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Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 2  
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 3.573 SNIP 1.866  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 3.859 SNIP 1.897  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 4.094 SNIP 1.765  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 3.7 SNIP 1.981  
Web of Science (2007): Indexed yes  
Scopus rating (2006): SJR 3.41 SNIP 1.924  
Web of Science (2006): Indexed yes
Brain Tumor Segmentation Using a Generative Model with an RBM Prior on Tumor Shape

In this paper, we present a fully automated generative method for brain tumor segmentation in multi-modal magnetic resonance images. The method is based on the type of generative model often used for segmenting healthy brain tissues, where tissues are modeled by Gaussian mixture models combined with a spatial atlas-based tissue prior. We extend this basic model with a tumor prior, which uses convolutional restricted Boltzmann machines (cRBMs) to model the shape of both tumor core and complete tumor, which includes edema and core. The cRBMs are trained on expert segmentations of training images, without the use of the intensity information in the training images. Experiments on public benchmark data of patients suffering from low- and high-grade gliomas show that the method performs well compared to current state-of-the-art methods, while not being tied to any specific imaging protocol.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Authors: Agn, M. (Intern), Puonti, O. (Intern), Rosenschöld, P. M. A. (Ekstern), Law, I. (Ekstern), Van Leemput, K. (Intern)
Pages: 168-180
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Host publication information

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Series: Lecture Notes in Computer Science
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ISSN: 0302-9743
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Workshop: 1st International Workshop on Brainlesion: Glioma, Multiple Sclerosis, Stroke and Traumatic Brain Injuries (Brainles 2015), Munich, Germany, 05/10/2015 - 05/10/2015
DOIs: 10.1007/978-3-319-30858-6_15
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Change detection in a short time sequence of polarimetric C-band SAR data

Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution and a factorization of this test statistic with associated p-values, change analysis in a time series of multilook, polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change(s) occur. The technique is demonstrated on airborne EMISAR C-band data.
but may be applied to ALOS, COSMO-SkyMed, RadarSat-2 Sentinel-1, TerraSAR-X, and Yaogan data also.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern)
Number of pages: 6
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Article number: 343
ISSN: 0379-6566
Main Research Area: Technical/natural sciences
Conference: ESA Living Planet Symposium 2016, Prague, Czech Republic, 09/05/2016 - 09/05/2016
Electronic versions:
imm6928_1.pdf
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Source-ID: 2346496249
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Change detection in a time series of polarimetric SAR data by an omnibus test statistic and its factorization
Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a short sequence of multilook, polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change(s) occur. The technique is demonstrated on airborne EMISAR L-band data but may be applied to Sentinel-1, Cosmo-SkyMed, TerraSAR-X, ALOS and RadarSat-2 or other dual- and quad/full-pol, and even single-pol data also.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern)
Number of pages: 2
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Series: Proceedings of SPIE - International Society for Optical Engineering
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Cochlear implant electrode localization in post-operative CT using a spherical measure
When implanting cochlear implants the positions of electrodes have a large impact on the quality of the restored hearing. Due to metal artifacts it is difficult to estimate the precise location in post-operative scans. In this paper we present a method for automatically locating and determining the ordering of electrode contacts on implanted electrode arrays from
Our method applies a specialized filter chain to the images based on a threshold and spherical measure, and selects contact positions at local maxima in the filtered image. Two datasets of 13 temporal bone specimens scanned in CBCT are used to validate the method, which successfully locates the electrode array in every image.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Scientific Computing, Copenhagen Center for Health Technology, MED-EL Medical Electronics, University of Bern, Universitat Pompeu Fabra
Authors: Braithwaite, B. M. (Intern), Kjer, H. M. (Intern), Fagertun, J. (Intern), González Ballester, M. A. (Ekstern), Dhansingh, A. (Ekstern), Mistrik, P. (Ekstern), Gerber, N. (Ekstern), Paulsen, R. R. (Intern)
Pages: 1329-1333
Publication date: 2016

Title of host publication: Proceedings of the 13th IEEE International Symposium on Biomedical Imaging (ISBI 2016)
Publisher: IEEE
ISBN (Electronic): 978-1-4799-2349-6
Main Research Area: Technical/natural sciences
Conference: 13th IEEE International Symposium on Biomedical Imaging, Prague, Czech Republic, 13/04/2016 - 13/04/2016
Cochlear Implant, Electrode array
DOIs: 10.1109/ISBI.2016.7493512
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Cochlear Implant, Electrode array

Cochlea Segmentation using Iterated Random Walks with Shape Prior
Cochlear implants can restore hearing to deaf or partially deaf patients. In order to plan the intervention, a model from high resolution μCT images is to be built from accurate cochlea segmentations and then, adapted to a patient-specific model. Thus, a precise segmentation is required to build such a model. We propose a new framework for segmentation of μCT cochlear images using random walks where a region term is combined with a distance shape prior weighted by a confidence map to adjust its influence according to the strength of the image contour. Then, the region term can take advantage of the high contrast between the background and foreground and the distance prior guides the segmentation to the exterior of the cochlea as well as to less contrasted regions inside the cochlea. Finally, a refinement is performed preserving the topology using a topological method and an error control map to prevent boundary leakage. We tested the proposed approach with 10 datasets and compared it with the latest techniques with random walks and priors. The experiments suggest that this method gives promising results for cochlea segmentation.

General information
State: Published
Authors: Ruiz Pujadas, E. (Ekstern), Kjer, H. M. (Intern), Vera, S. (Ekstern), Ceresa, M. (Ekstern), González Ballester, M. A. (Ekstern)
Number of pages: 9
Publication date: 2016

Title of host publication: Proceedings of SPIE
Volume: 9784
Publisher: SPIE - International Society for Optical Engineering
Series: S P I E - International Society for Optical Engineering. Proceedings
Volume: 9784
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Main Research Area: Technical/natural sciences
Conference: SPIE Medical Imaging 2016, San Diego, California, United States, 27/02/2016 - 27/02/2016
Random walks, Shape prior, Distance map, Segmentation, Cochlea
Electronic versions: Cochlea_Segmentation.pdf
DOIs: 10.1117/12.2208675
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017
Computational Analysis of Brain Images: Towards a Useful Tool in Clinical Practice

Due to its excellent soft tissue contrast and versatility, magnetic resonance imaging (MRI) has become arguably the most important tool for studying the structure and disorders of the human brain. Although in recent years tremendous advances have been made in automatic segmentation of brain MRI scans, many of the developed methods are not readily extendible to clinical applications due to the variability of clinical MRI data and the presence of pathologies, such as tumors or lesions. Thus, clinicians are forced to manually analyze the MRI data, which is a time consuming task and introduces rater-dependent variability that reduces the accuracy and sensitivity of the results.

The goal of this PhD-project was to enlarge the scope of the automatic tools into clinical applications. In order to tackle the variability of the data and presence of pathologies, we base our methods on Bayesian generative modeling, which combines detailed prior models of the human neuroanatomy and pathologies with models of the MRI imaging process. This approach allows us to describe the observed MRI data in a principled manner, and to integrate explicit models of different disease effects and imaging artifacts into the framework when needed.

This thesis presents an introduction to the theory behind the generative modeling approach, and an overview of the main results. The first part concentrates on segmenting different neuroanatomical structures in MRI scans of healthy subjects, and the second part describes how this framework can be extended with models of brain lesions. This results in a set of fast, robust and fully automatic tools for segmenting MRI brain scans of both healthy subjects and patients suffering from brain disorders such as multiple sclerosis. Having access to quantitative measures of both lesions and the surrounding structures opens up avenues for clinicians to study the effect of these type of disorders on the full brain anatomy. This could potentially help in discovering sensitive biomarkers for early diagnosis and tracking of disease development.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Puonti, O. (Intern), Van Leemput, K. (Intern), Larsen, R. (Intern)
Number of pages: 180
Publication date: 2016

Computed tomography synthesis from magnetic resonance images in the pelvis using multiple random forests and auto-context features

In radiotherapy treatment planning that is only based on magnetic resonance imaging (MRI), the electron density information usually obtained from computed tomography (CT) must be derived from the MRI by synthesizing a so-called pseudo CT (pCT). This is a non-trivial task since MRI intensities are neither uniquely nor quantitatively related to electron density. Typical approaches involve either a classification or regression model requiring specialized MRI sequences to solve intensity ambiguities, or an atlas-based model necessitating multiple registrations between atlases and subject scans. In this work, we explore a machine learning approach for creating a pCT of the pelvic region from conventional MRI sequences without using atlases. We use a random forest provided with information about local texture, edges and spatial features derived from the MRI. This helps to solve intensity ambiguities. Furthermore, we use the concept of auto-context by sequentially training a number of classification forests to create and improve context features, which are finally used to train a regression forest for pCT prediction. We evaluate the pCT quality in terms of the voxel-wise error and the radiologic accuracy as measured by water-equivalent path lengths. We compare the performance of our method against two baseline pCT strategies, which either set all MRI voxels in the subject equal to the CT value of water, or in addition transfer the bone volume from the real CT. We show an improved performance compared to both baseline pCTs suggesting that our method may be useful for MRI-only radiotherapy.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen, University of Munich
Authors: Andreasen, D. (Intern), Morgenthaler Edmund, J. (Ekstern), Zografos, V. (Ekstern), Menze, B. H. (Ekstern), Van Leemput, K. (Intern)
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Article number: 978417
Main Research Area: Technical/natural sciences
Conference: SPIE Medical Imaging 2016, San Diego, California, United States, 27/02/2016 - 27/02/2016
Radiotherapy, Magnetic resonance imaging, Pseudo CT, CT synthesis, Random forest, Auto-context
Electronic versions:
computed_tomography_synthesis_11_submitted_version.pdf
DOIs:
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Source: PublicationPreSubmission
Source-ID: 125111640
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Contact area measurements on structured surfaces
In connection with the use of brass specimens featuring structured surfaces in a tribology test, an algorithm was developed for automatic measurement of the contact area by optical means.

General information
State: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Küçükyıldız, Ö. C. (Intern), Jensen, S. H. N. (Intern), De Chiffre, L. (Intern)
Number of pages: 1
Publication date: 2016
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Main Research Area: Technical/natural sciences
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Source: PublicationPreSubmission
Source-ID: 128476167
Publication: Research - peer-review › Poster – Annual report year: 2017

Cuttable Ruled Surface Strips for Milling
This paper proposes a novel pre-processing method for industrial robotic CNC-milling. The method targets a hybrid machining process, in which the main bulk of material is removed through robotic hot or abrasive wire cutting, after which regular CNC-machining is employed for removal of the remaining material volume. Hereby, the roughing process is significantly sped up, reducing overall machining time. We compare our method to the convex hull and remove between 5% and 75% more material; on most models we obtain a 50% improvement. Our method ensures that no overcutting happens and that the result is cuttable by wire cutting.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Mathematics, Odico Formwork Robotics Aps
Authors: Steenstrup, K. H. (Intern), Nørnbjerg, T. B. (Intern), Søndergaard, A. (Ekstern), Bærentzen, J. A. (Intern), Gravesen, J. (Intern)
Pages: 328-342
Publication date: 2016

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Editors: Adriaenssens, S., Gramazio, F., Kohler, M., Menges, A., Pauly, M.
ISBN (Print): 978-3-7281-3778-4
Main Research Area: Technical/natural sciences
Piecewise-ruled surfaces, CAD, Milling, Free form architecture
Data Analysis of Medical Images: CT, MRI, Phase Contrast X-ray and PET

Data analysis of medical images is an important and growing area, as systems for imaging becomes still more available and complex.

The goal of the thesis is to demonstrate solutions to data analysis problems in a cross disciplinary context. Further, to develop methods for analysis of new imaging modalities and to combine cross disciplinary knowledge from various fields to find new solutions to existing problems.

More specifically the thesis shows segmentation of images, classification and statistics used on a variety of quite different problems. Active Appearance models, Chan-Vese and graph-cut has been used, as well as a variety of statistical tools centred on the General Linear Model.

The point of departure for the thesis is the NanoGuide project, in which gel based x-ray markers for use in radiotherapy has been developed. Two different types of gels has been analysed using segmentation of micro-CT images followed by a statistical analysis of homogeneity, contrast, degradation, and other qualities. By combining knowledge from the different professions in the project, a new application for one of the developed gels - in-vivo dosimetry in radiotherapy - has been studied.

Analysis of differences between groups and of correlations between brain regions and cognitive tests in alzheimers patients is another contribution. Segmentation of fat in abdominal MRI-scans has also been studied and a robust algorithm based on graph-cut is presented.

A relatively new modality phase-contrast x-ray and dark-field has shown promise for diagnosis of a variety of diseases in the lungs. A classification algorithm for differentiation of healthy, emphysematous and fibrotic lung tissue on pixel level is presented.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science , Image Analysis & Computer Graphics
Authors: Christensen, A. N. (Intern), Conradsen, K. (Intern), Larsen, R. (Intern)
Number of pages: 224
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Original language: English
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Number: 386
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Main Research Area: Technical/natural sciences
Electronic versions:
phd386_Christensen_AN.pdf
Publication: Research › Ph.D. thesis – Annual report year: 2016

DeepPy: Pythonic deep learning
This technical report introduces DeepPy – a deep learning framework built on top of NumPy with GPU acceleration. DeepPy bridges the gap between high-performance neural networks and the ease of development from Python/NumPy. Users with a background in scientific computing in Python will quickly be able to understand and change the DeepPy codebase as it is mainly implemented using high-level NumPy primitives. Moreover, DeepPy supports complex network architectures by letting the user compose mathematical expressions as directed graphs. The latest version is available at http://github.com/andersbil/deeppy under the MIT license.
Designing for Color in Additive Manufacturing
In this paper we present a color design pipeline for 3D printed or additively manufactured parts. We demonstrate how to characterize and calibrate a commercial printer and how to obtain its forward and backward color transformation models. We present results from our assistive color design tool, allowing for colorimetric accurate prints and visualization of the printed outcome, prior to print. Lastly, we demonstrate our pipeline by accurately reproducing a real physical object.

Designing for hot-blade cutting: Geometric Approaches for High-Speed Manufacturing of Doubly-Curved Architectural Surfaces
In this paper we present a novel method for the generation of doubly-curved, architectural design surfaces using swept Euler elastica and cubic splines. The method enables a direct design to production workflow with robotic hot-blade cutting, a novel robotic fabrication method under development by authors of the paper, which facilitates high-speed production of doubly-curved foam moulds. Complementary to design rationalisation, in which arbitrary surfaces are translated to hot-blade-cutable geometries, the presented method enables architects and designers to design directly with the non-trivial constraints of blade-cutting in a bottom-up fashion, enabling an exploration of the unique architectural potential of this fabrication approach. The method is implemented as prototype design tools in MatLAB, C++, GhPython, and Python and demonstrated through cutting of expanded polystyrene foam design examples.
Determining the Points of Change in Time Series of Polarimetric SAR Data

We present the likelihood ratio test statistic for the homogeneity of several complex variance–covariance matrices that may be used in order to assess whether at least one change has taken place in a time series of SAR data. Furthermore, we give a factorization of this test statistic into a product of test statistics that each tests simpler hypotheses of homogeneity up to a certain point and that are independent if the hypothesis of total homogeneity is true. This factorization is used in determining the (pixelwise) time points of change in a series of six L-band EMISAR polarimetric SAR data. The pixelwise analyses are applied on homogeneous subareas covered with different vegetation types using the distribution of the observed p-values.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Skriver, H. (Intern)
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 5.29 SJR 2.461 SNIP 3.102
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.559 SNIP 3.241 CiteScore 4.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.467 SNIP 3.355 CiteScore 4.22
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.382 SNIP 3.806 CiteScore 4.26
Magnetic resonance imaging (MRI) is the de facto modality in neuroimaging studies, due to its superior image contrast in soft tissue. These studies often employ automated software pipelines that segments the image into structures and tissue. This reduces the time needed for analysis as well as statistical bias that may arise due to disagreements in delineations made by human experts. One such pipeline is Freesurfer.

This thesis presents results from the intervention study "Preserving cognition, quality of life, physical health and functional ability in Alzheimer's disease: the effect of physical exercise" (ADEX), where longitudinal Freesurfer analysis was used to obtain segmentations of the hippocampal subfields and cortical regions in a subgroup of participants before and after a four-month exercise period. The participants performed moderate-to-high aerobic exercise for one hour, three times per week. The study hypothesized that the intervention would lead to reduced loss of tissue in the hippocampus and cortical regions, and that volumetric changes over time would correlate with cognitive performance measures. It was not possible to measure any effects in the hippocampus or cortical regions due to the intervention. However, it was found that exercise
load (attendance and training intensity) correlated with changes in the hippocampus and in frontal and cingulate cortical thickness. Furthermore, changes in frontal and cingulate cortical thickness were found to correlate with changes in several cognitive performance measures, including mental speed, attention and verbal fluency.

MRI suffers from an image artifact often referred to as the "bias field". This effect complicates automatized analysis of the images. For this reason, bias field correction is typical an early preprocessing step in many pipelines. Freesurfer currently employs the popular N3 bias field correction algorithm early in the pipeline, to solve this problem.

In this thesis, the reader is introduced to generative models for bias field correction. It is further shown how N3, which has traditionally been described as a "histogram sharpening" method, actually employs an underlying generative model, and that the bias field is estimated using an algorithm that is identical to generalized expectation maximization, but relies on heuristic parameter updates.

The thesis progresses to present a new generative model for longitudinal correction of the bias field, as well as a model that does not require brain masking or probabilistic, anatomical atlases in order to perform well. Finally, the thesis presents the realization of these models in the software package "Intensity Inhomogeneity Correction", which will be made publicly available.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Larsen, C. T. (Intern), Van Leemput, K. (Intern)
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Publisher: Technical University of Denmark (DTU)
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phd378_Larsen_CT.pdf
Publication: Research › Ph.D. thesis – Annual report year: 2016

Fast and Sequence-Adaptive Whole-Brain Segmentation Using Parametric Bayesian Modeling
Quantitative analysis of magnetic resonance imaging (MRI) scans of the brain requires accurate automated segmentation of anatomical structures. A desirable feature for such segmentation methods is to be robust against changes in acquisition platform and imaging protocol. In this paper we validate the performance of a segmentation algorithm designed to meet these requirements, building upon generative parametric models previously used in tissue classification. The method is tested on four different datasets acquired with different scanners, field strengths and pulse sequences, demonstrating comparable accuracy to state-of-the-art methods on T1-weighted scans while being one to two orders of magnitude faster. The proposed algorithm is also shown to be robust against small training datasets, and readily handles images with different MRI contrast as well as multi-contrast data.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School
Authors: Puonti, O. (Intern), Iglesias, J. E. (Ekstern), Van Leemput, K. (Intern)
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Volume: 143
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.573 SNIP 1.866
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.859 SNIP 1.897
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 4.094 SNIP 1.765
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.7 SNIP 1.981
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.41 SNIP 1.924
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.703 SNIP 1.918
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.401 SNIP 1.794
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.974 SNIP 1.003
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.885 SNIP 0.403
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.526 SNIP 0.253
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.534 SNIP 0.341
Scopus rating (1999): SJR 0.641 SNIP 0.494
Original language: English
MRI, Segmentation, Atlases, Parametric models, Bayesian modeling
Electronic versions:
Fast and sequence-adaptive
DOIs:
10.1016/j.neuroimage.2016.09.011
Better understanding of the anatomical variability of the human cochlear is important for the design and function of Cochlear Implants. Proper non-rigid alignment of high-resolution cochlear μCT data is a challenge for the typical cubic B-spline registration model. In this paper we study one way of incorporating skeleton-based similarity as an anatomical registration prior. We extract a centerline skeleton of the cochlear spiral, and generate corresponding parametric pseudo-landmarks between samples. These correspondences are included in the cost function of a typical cubic B-spline registration model to provide a more global guidance of the alignment. The resulting registrations are evaluated using different metrics for accuracy and model behavior, and compared to the results of a registration without the prior.
GyroVR: Simulating Inertia in Virtual Reality using Head Worn Flywheels

We present GyroVR, head worn flywheels designed to render inertia in Virtual Reality (VR). Motions such as flying, diving or floating in outer space generate kinesthetic forces onto our body which impede movement and are currently not represented in VR. We simulate those kinesthetic forces by attaching flywheels to the users head, leveraging the gyroscopic effect of resistance when changing the spinning axis of rotation. GyroVR is an ungrounded, wireless and self contained device allowing the user to freely move inside the virtual environment. The generic shape allows to attach it to different positions on the users body. We evaluated the impact of GyroVR onto different mounting positions on the head (back and front) in terms of immersion, enjoyment and simulator sickness. Our results show, that attaching GyroVR onto the users head (front of the Head Mounted Display (HMD)) resulted in the highest level of immersion and enjoyment and therefore can be built into future VR HMDs, enabling kinesthetic forces in VR.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Ulm, MIT Media Lab
Authors: Gugenheimer, J. (Ekstern), Wolf, D. (Ekstern), Eiríksson, E. R. (Intern), Maes, P. (Ekstern), Rukzio, E. (Ekstern)
Pages: 227-232
Publication date: 2016

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Publisher: Association for Computing Machinery
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BFI conference series: User Interface Software and Technology (5000294)
Main Research Area: Technical/natural sciences
Conference: 29th Annual Symposium on User Interface Software and Technology (UIST '16), Tokyo, Japan, 16/10/2016 - 16/10/2016
GyroVR, Haptics, Virtual reality, Mobil VR, Nomadic VR
DOIs: 10.1145/2984511.2984535
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Source-ID: 126653718
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
Hot Blade Cuttings for the Building Industries

The constructions of advanced architectural designs are presently very labour intensive, time consuming, and expensive. They are therefore only applied to a few prestige projects, and it is a major challenge for the building industry to bring the costs down and thereby offer the architects more variability in the (economically allowed) designs - i.e., to allow them to think out of the box. To address this challenge The Danish National Advanced Technology Foundation (now InnovationsFonden) is currently supporting the BladeRunner project that involves several Danish companies and public institutions. The project aims to reduce the amount of manual labour as well as production time by applying robots to cut expanded polystyrene (EPS) moulds for the concrete to form doubly curved surfaces. The scheme is based upon the so-called Hot Wire or Hot Blade technology where the surfaces are essentially swept out by driving an Euler elastica through a block of EPS. This paper will be centered around the mathematical challenges encountered in the implementation of this idea. Since the elastica themselves are well known and described in the works of Euler et al. already in eighteenth century, these new challenges are mainly concerned with the rationalization of the architects’ CAD drawings into surfaces that can be created via this particular sweeping and cutting technology.

General information
State: Published
Authors: Brander, D. (Intern), Bærentzen, J. A. (Intern), Evgrafov, A. (Ekstern), Gravesen, J. (Intern), Markvorsen, S. (Intern), Nørøjberg, T. B. (Intern), Nørbjerg, T. B. (Intern), Nørtoft, P. (Intern), Steenstrup, K. H. (Intern)
Number of pages: 19
Publication date: 2016

Hybrid fur rendering: combining volumetric fur with explicit hair strands

Hair is typically modeled and rendered using either explicitly defined hair strand geometry or a volume texture of hair densities. Taken each on their own, these two hair representations have difficulties in the case of animal fur as it consists of very dense and thin undercoat hairs in combination with coarse guard hairs. Explicit hair strand geometry is not well-suited for the undercoat hairs, while volume textures are not well-suited for the guard hairs. To efficiently model and render both guard hairs and undercoat hairs, we present a hybrid technique that combines rasterization of explicitly defined guard hairs with ray marching of a prismatic shell volume with dynamic resolution. The latter is the key to practical combination of the two techniques, and it also enables a high degree of detail in the undercoat. We demonstrate that our hybrid technique creates a more detailed and soft fur appearance as compared with renderings that only use explicitly defined hair strands. Finally, our rasterization approach is based on order-independent transparency and renders high-quality fur images in seconds.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Technical University of Denmark
Authors: Andersen, T. G. (Intern), Falster, V. (Ekstern), Frisvad, J. R. (Intern), Christensen, N. J. (Intern)
Pages: 739-749
Publication date: 2016
Main Research Area: Technical/natural sciences
Identification of Dynamic Cover Types in Wetlands by using Multitemporal Cross-polarized Sentinel-1 Images

Monitoring of long-term land-use and land-cover change patterns may be biased by seasonal changes of different surface properties (e.g. hydrology, phenology, etc.) which become even more prominent in highly dynamic ecosystems such as wetlands (Crews-Meyer, 2008; McClearly, Crews-Meyer and Young 2008; Dronova et al. 2011). These surface dynamics produce transitional states and fine-scale mixtures of classes that may hinder classifications and long-term change detection. Dronova et al. (2015) proposed the term “Dynamic Cover Types” (DCT) to refer to such areas of regimes of periodic or seasonal change. Examples of DCT in the context of wetlands would be seasonally inundated forests, temporal water bodies and waterways, or harvests of reeds and crops such as rice. We assess the spatio-temporal extent of DCT in two study sites; The Camargue, a large coastal wetland in Southern France, and the Lagoon of Fuente de Piedra, a small wetland in Southern Spain. For that we use a multitemporal change detection procedure for polarimetric SAR imagery based on the Complex Wishart distribution developed recently by Conradsen et al (2015), (to be published) and an innovative open source software implementation which makes use of Ipython Notebooks and Docker containers (http://mortcanty.github.io/SARDocker/). The procedure carries out a series of change detection processing routines for the whole time series with a desired significance level. It uses multilook, geocoded and terrain corrected intensity images in C2 matrix. These were generated in the Sentinel Application Platform (SNAP) using 12 Sentinel-1 images.
Interferometric Wide, Single Look Complex and cross-polarized) with a monthly resolution. The methodology proposed here for change detection is relatively easy to use and utilizes only open source and free data. It enables an operational monitoring service of short-term change detection. No calibration or validation needed, only interpretation of changes using local knowledge. This has important implications for operational standardized monitoring service such as the ones developed in the Satellite-based Wetland Observation Service (SWOS) Horizon 2020 project. Besides its easiness to use, this methodology has other important advantages: First, the fine spatial and temporal resolutions of Sentinel-1 SAR data allow us to detect short-time changes for a complete water year regardless of the cloud cover. Second, change detection methods based on classification are affected by classification errors, whose probability of occurrence increases in dynamic and transitional landscapes (Powell et al. 2003). Our approach does not rely on classification and thus is free from such errors. Third, DCT are complex landscapes that often give rise to unique species assemblages (Parrot & Meyer 2012; Watson et al. 2014), and knowing their spatio-temporal extent will assist in biodiversity management. Fourth, annual stable features can be identified and used for training areas, which may facilitate the classification process and improve accuracies. And fifth, estimating the spatio-temporal extent of DCT might shed some light on the wide array of options in classification methodologies available and their different results (Object vs. Pixel based, Support Vector Machines, Random Forest Classifiers, and other algorithms).

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing, University of Bonn, Jena Optronik GMBH, Research Center Jülich GmbH
Authors: Muro, J. (Ekstern), Canty, M. (Ekstern), Conradsen, K. (Intern), Hüttich, C. (Ekstern), Menz, G. (Ekstern), Nielsen, A. A. (Intern), Skriver, H. (Intern), Strauch, A. (Ekstern), Thonfeld, F. (Ekstern)
Number of pages: 1
Publication date: 2016
Event: Abstract from ESA Living Planet Symposium 2016, Prague, Czech Republic.
Main Research Area: Technical/natural sciences
Links: http://lps16.esa.int/page_session109.php#1005p
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Improving topology optimization intuition through games
This paper describes the educational game, TopOpt Game, which invites the player to solve various optimization challenges. The main purpose of gamifying topology optimization is to create a supplemental educational tool which can be used to introduce concepts of topology optimization to newcomers as well as train human intuition of topology optimization. The players are challenged to solve the standard minimum compliance problem in 2D by distributing material in a design domain given a number of loads and supports with a material constraint. A statistical analysis of the gameplay data shows that players achieve higher scores the more they play the game. The game is freely available for the iOS platform at Apple's App Store and at http://www.topopt.dtu.dk/?q=node/909 for Win-dows and OSX.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Solid Mechanics, Acoustic Technology
Authors: Nobel-Jørgensen, M. (Intern), Malmgren-Hansen, D. (Intern), Bærentzen, J. A. (Intern), Sigmund, O. (Intern), Aage, N. (Intern)
Pages: 775–781
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Structural and Multidisciplinary Optimization
Volume: 54
Issue number: 4
ISSN (Print): 1615-147x
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.14
Web of Science (2016): Indexed yes
Independent vector analysis for capturing common components in fMRI group analysis

Independent component analysis (ICA) is a widely used blind source separation method for decomposing resting state functional magnetic resonance imaging (rs-fMRI) data into latent components. However, it can be challenging to obtain subject-specific component representations in multi-subject studies. Independent vector analysis (IVA) is a promising alternative approach to perform group fMRI analysis, which has been shown to better capture components with high inter-subject variability. The most widely applied IVA method is based on the multivariate Laplace distribution (IVA-GL), which assumes independence within subject components coupled across subjects only through shared scaling. In this study, we propose a more natural formulation of IVA based on a Normal-Inverse-Gamma distribution (IVA-NIG), in which the components can be directly interpreted as realizations of a common mean component with individual subject variability. We evaluate the performance of IVA-NIG compared to IVA-GL and similar decomposition methods, through the application of two types of simulated data and on real task fMRI data. The results show that IVA-NIG offers superior detection of components in simulated fMRI data. On real fMRI data with low inter-subject variability we find that all methods identify similar and plausible components.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Cognitive Systems, Copenhagen University Hospital
Individual Differences in the Alignment of Structural and Functional Markers of the V5/MT Complex in Primates

Extrastriate visual area V5/MT in primates is defined both structurally by myeloarchitecture and functionally by distinct responses to visual motion. Myelination is directly identifiable from postmortem histology but also indirectly by image contrast with structural magnetic resonance imaging (sMRI). First, we compared the identification of V5/MT using both sMRI and histology in Rhesus macaques. A section-by-section comparison of histological slices with in vivo and postmortem sMRI for the same block of cortical tissue showed precise correspondence in localizing heavy myelination for V5/MT and neighboring MST. Thus, sMRI in macaques accurately locates histologically defined myelin within areas known to be motion selective. Second, we investigated the functionally homologous human motion complex (hMT+) using high-resolution in vivo imaging. Humans showed considerable intersubject variability in hMT+ location, when defined with myelin-weighted sMRI signals to reveal structure. When comparing sMRI markers to functional MRI in response to moving stimuli, a region of high myelin signal was generally located within the hMT+ complex. However, there were considerable differences in the alignment of structural and functional markers between individuals. Our results suggest that variation in area identification for hMT+ based on structural and functional markers reflects individual differences in human regional brain architecture.
The folding of the cortex results in a characteristic pattern of folds called sulci and ridges called gyri. The cortical folding varies greatly both within and between individuals. Despite a century of sustained research, the mechanisms underlying the observed variation in folding is still largely unknown. The shape of cortical sulci and gyri are determined in part by forces exerted by white matter fiber connections between various cortical regions. Studying the shape of the cortical sulci hence contributes to the understanding of the variation in the folding.

This thesis concerns sulcal morphometry using Magnetic Resonance Imaging (MRI) and spatial statistical methods. The sulcal morphology has been studied with respect to: the normal development of a central sulcus; in relation to functional lateralization of the motor hand area in central sulcus and, finally, in relation to a pathological condition, anosmia, in the olfactory sulcus. This thesis describes and uses methods for sulci segmentation, sulci registration, sulci representation, and statistics for modeling sulci shape and testing sulcal morphology.

This thesis describes methods to analyze sulcal morphology and show how sulci variability are influenced under normal development, by a functional ability, and by pathological conditions.
Injectable silver nanosensors: in vivo dosimetry for external beam radiotherapy using positron emission tomography

Development of safe and efficient radiotherapy routines requires quantification of the delivered absorbed dose to the cancer tissue in individual patients. In vivo dosimetry can provide accurate information about the absorbed dose delivered during treatment. In the current study, a novel silver-nanosensor formulation based on poly(vinylpyrrolidinone)-coated silver nanoparticles formulated in a gelation matrix composed of sucrose acetate isobutyrate has been developed for use as an in vivo dosimeter for external beam radiotherapy. In situ photonuclear reactions trigger the formation of radioactive $^{106}$Ag, which enables post treatment verification of the delivered dose using positron emission tomography imaging. The silver-nanosensor was investigated in a tissue equivalent thorax phantom using clinical settings and workflow for both standard fractionated radiotherapy (2 Gy) and stereotactic radiotherapy (10- and 22 Gy) in a high-energy beam setting (18 MV). The developed silver-nanosensor provided high radiopacity on the planning CT-scans sufficient for patient positioning in image-guided radiotherapy and provided dosimetric information about the absorbed dose with a 10% and 8% standard deviation for the stereotactic regimens, 10 and 22 Gy, respectively.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Micro- and Nanotechnology, Colloids and Biological Interfaces, University of Copenhagen, Copenhagen University Hospital, Technical University of Denmark
Authors: Christensen, A. N. (Intern), Rydhög, J. S. (Ekstern), Søndergaard, R. V. (Intern), Andresen, T. L. (Intern), Holm, S. (Ekstern), Munck af Rosenschöld, P. (Ekstern), Conradsen, K. (Intern), Jølck, R. I. (Ekstern)
Pages: 11002-11011
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Nanoscale
Volume: 8
Issue number: 21
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.46 SJR 2.769 SNIP 1.459
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.842 SNIP 1.588 CiteScore 7.97
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.651 SNIP 1.676 CiteScore 7.64
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
In-Situ Monitoring in Additive Manufacturing Using Contact Image Sensors

**General information**
State: Published
Organisations: Department of Mechanical Engineering, Manufacturing Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Pages: 114-118
Publication date: 2016

**Host publication information**
Title of host publication: Proceedings of the ASPE/euspen 2016 Summer Topical Meeting on Dimensional Accuracy and Surface Finish in Additive Manufacturing
Publisher: ASPE – The American Society for Precision Engineering
ISBN (Print): 9781887706711
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 124883782
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Interactive Appearance Prediction for Cloudy Beverages

Juice appearance is important to consumers, so digital juice with a slider that varies a production parameter or changes juice content is useful. It is however challenging to render juice with scattering particles quickly and accurately. As a case study, we create an appearance model that provides the optical properties needed for rendering of unfiltered apple juice. This is a scattering medium that requires volume path tracing as the scattering is too much for single scattering techniques and too little for subsurface scattering techniques. We investigate techniques to provide a progressive interactive appearance prediction tool for this type of medium. Our renderings are validated by qualitative and quantitative comparison with photographs. Visual comparisons using our interactive tool enable us to estimate the apple particle concentration of a photographed apple juice.

**General information**
State: Published
Organisations: IT Service, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Alexandra Institute
Authors: Dal Corso, A. (Intern), Frisvad, J. R. (Intern), Kjeldsen, T. K. (Ekstern), Bærentzen, J. A. (Intern)
Number of pages: 4
Publication date: 2016

**Host publication information**
Title of host publication: MAM2016: Eurographics Workshop on Material Appearance Modeling
Publisher: Eurographics
Editors: Klein, R., Rushmeier, H.
Interactive directional subsurface scattering and transport of emergent light

Existing techniques for interactive rendering of deformable translucent objects can accurately compute diffuse but not directional subsurface scattering effects. It is currently a common practice to gain efficiency by storing maps of transmitted irradiance. This is, however, not efficient if we need to store elements of irradiance from specific directions. To include changes in subsurface scattering due to changes in the direction of the incident light, we instead sample incident radiance and store scattered radiosity. This enables us to accommodate not only the common distance-based analytical models for subsurface scattering but also directional models. In addition, our method enables easy extraction of virtual point lights for transporting emergent light to the rest of the scene. Our method requires neither preprocessing nor texture parameterization of the translucent objects. To build our maps of scattered radiosity, we progressively render the model from different directions using an importance sampling pattern based on the optical properties of the material. We obtain interactive frame rates, our subsurface scattering results are close to ground truth, and our technique is the first to include interactive transport of emergent light from deformable translucent objects.
Interactive Topology Optimization

Interactivity is the continuous interaction between the user and the application to solve a task. Topology optimization is the optimization of structures in order to improve stiffness or other objectives. The goal of the thesis is to explore how topology optimization can be used in applications in an interactive and intuitive way. By creating such applications with an intuitive and simple user interface we allow non-engineers like designers and architects to easily experiment with boundary conditions, design domains and other optimization settings. This is in contrast to commercial topology optimization software where the users are assumed to be well-educated both in the finite element method and topology optimization.

This dissertation describes how various topology optimization methods have been used for creating cross-platform applications with high performance. The user interface design is based on theory of from human-computer interaction which is described in Chapter 2. Followed by a description of the foundations of topology optimization in Chapter 3. Our applications for topology optimization in 2D and 3D are described in Chapter 4 and a game which trains the human intuition of topology optimization is presented in Chapter 5. Topology optimization can also be used as an interactive modeling tool with local control which is presented in Chapter 6. Finally, Chapter 7 contains a summary of the findings and concludes the dissertation.

Most of the presented applications of the thesis are available at: http://www.topopt.dtu.dk.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Nobel-Jørgensen, M. (Intern), Bærentzen, J. A. (Intern)
Number of pages: 124
Publication date: 2016

Publication information

Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English

Series: DTU Compute PHD-2015
Number: 375
ISSN: 0909-3192
Main Research Area: Technical/natural sciences
Iterated random walks with shape prior

We propose a new framework for image segmentation using random walks where a distance shape prior is combined with a region term. The shape prior is weighted by a confidence map to reduce the influence of the prior in high gradient areas and the region term is computed with k-means to estimate the parametric probability density function. Then, random walks is performed iteratively aligning the prior with the current segmentation in every iteration. We tested the proposed approach with natural and medical images and compared it with the latest techniques with random walks and shape priors. The experiments suggest that this method gives promising results for medical and natural images.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Universitat Pompeu Fabra
Authors: Pujadas, E. R. (Ekstern), Kjer, H. M. (Intern), Piella, G. (Ekstern), González Ballester, M. A. (Ekstern)
Pages: 12-21
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Image and Vision Computing
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ISSN (Print): 0262-8856
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.087 SNIP 1.733 CiteScore 3.31
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.264 SNIP 1.987 CiteScore 3.36
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.787 SNIP 2.172 CiteScore 2.8
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.157 SNIP 3.451 CiteScore 3.92
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.014 SNIP 3.519 CiteScore 3.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.861 SNIP 2.755 CiteScore 3.16
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.839 SNIP 2.134
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.911 SNIP 2.226
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.847 SNIP 1.806
Scopus rating (2007): SJR 0.862 SNIP 1.884
Scopus rating (2006): SJR 1.044 SNIP 2.787
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.892 SNIP 2.72
Scopus rating (2004): SJR 0.588 SNIP 2.06
Large-Scale Data for Multiple-View Stereoscopy

The seminal multiple-view stereo benchmark evaluations from Middlebury and by Strecha et al. have played a major role in propelling the development of multi-view stereopsis (MVS) methodology. The somewhat small size and variability of these data sets, however, limit their scope and the conclusions that can be derived from them. To facilitate further development within MVS, we here present a new and varied data set consisting of 80 scenes, seen from 49 or 64 accurate camera positions. This is accompanied by accurate structured light scans for reference and evaluation. In addition all images are taken under seven different lighting conditions. As a benchmark and to validate the use of our data set for obtaining reasonable and statistically significant findings about MVS, we have applied the three state-of-the-art MVS algorithms by Campbell et al., Furukawa et al., and Tola et al. to the data set. To do this we have extended the evaluation protocol from the Middlebury evaluation, necessitated by the more complex geometry of some of our scenes. The data set and accompanying evaluation framework are made freely available online. Based on this evaluation, we are able to observe several characteristics of state-of-the-art MVS, e.g. that there is a tradeoff between the quality of the reconstructed 3D points (accuracy) and how much of an object’s surface is captured (completeness). Also, several issues that we hypothesized would challenge MVS, such as specularities and changing lighting conditions did not pose serious problems. Our study finds that the two most pressing issues for MVS are lack of texture and meshing (forming 3D points into closed triangulated surfaces).

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Aston University, Aurvis R&D
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Main Research Area: Technical/natural sciences

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Journal: International Journal of Computer Vision
Volume: 120
Issue number: 2
ISSN (Print): 0920-5691
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 11.06 SJR 8.269 SNIP 5.054
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.726 SNIP 4.329 CiteScore 6.81
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.834 SNIP 4.735 CiteScore 6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.767 SNIP 5.083 CiteScore 7.59
Learned image representations for visual recognition

This thesis addresses the problem of extracting image structures for representing images effectively in order to solve visual recognition tasks. Problems from diverse research areas (medical imaging, material science and food processing) have motivated large parts of the methodological development. The solutions are inspired by and extend state-of-the-art techniques for describing and learning image content.

More specifically, the thesis explores two approaches to constructing image representations, namely feature engineering...
and feature learning. In the feature engineering approach, we devise a new image representation for texture-like patterns based on count statistics of second-order image structure. We demonstrate the discriminative capabilities of this representation on medical images and perform both cell classification and mitosis detection. Moreover, we develop an object identification method based on vector quantized local image descriptors allowing us to distinguish individual meat cuts along a production line and trace them in a non-intrusive manner. In the feature learning approach, we propose to solve the task of segmenting scanning electron microscopy images of calcite crystals by learning a meaningful pixel description to facilitate the actual segmentation. Finally, we present a new unsupervised generative image model addressing the problem of pixel-based similarity measures for images. We propose a scheme for employing feature-based similarity measures and demonstrate how this improves the ability to learn high-level concepts in images of faces.

The thesis argues in favor of learning features and presents new methods for domains with limited amounts of labeled data allowing feature learning to be applied more broadly.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Larsen, A. B. L. (Intern), Larsen, R. (Intern), Dahl, A. B. (Intern)
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Publication date: 2016

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phd418_Larsen_ABL.pdf
Publication: Research › Ph.D. thesis – Annual report year: 2016

**Mimetic Divergence and the Speciation Continuum in the Mimic Poison Frog Ranitomeya imitator**
While divergent ecological adaptation can drive speciation, understanding the factors that facilitate or constrain this process remains a major goal in speciation research. Here, we study two mimetic transition zones in the poison frog Ranitomeya imitator, a species that has undergone a Mullerian mimetic radiation to establish four morphs in Peru. We find that mimetic morphs are strongly phenotypically differentiated, producing geographic clines with varying widths. However, distinct morphs show little neutral genetic divergence, and landscape genetic analyses implicate isolation by distance as the primary determinant of among-population genetic differentiation. Mate choice experiments suggest random mating at the transition zones, although certain allopatric populations show a preference for their own morph. We present evidence that this preference may be mediated by color pattern specifically. These results contrast with an earlier study of a third transition zone, in which a mimetic shift was associated with reproductive isolation. Overall, our results suggest that the three known mimetic transition zones in R. imitator reflect a speciation continuum, which we have characterized at the geographic, phenotypic, behavioral, and genetic levels. We discuss possible explanations for variable progress toward speciation, suggesting that multifarious selection on both mimetic color pattern and body size may be responsible for generating reproductive isolation.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, East Carolina University, Centro de Ornitologia y Biodiversidad
Authors: Twomey, E. (Ekstern), Vestergaard, J. S. (Intern), Venegas, P. J. (Ekstern), Summers, K. (Ekstern)
Number of pages: 20
Pages: 205-224
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**
Journal: The American Naturalist
Volume: 187
Issue number: 2
ISSN (Print): 0003-0147
Ratings:
BFI (2018): BFI-level 2
We develop a method to acquire the BRDF of a homogeneous flat sample from only two images, taken by a near-field perspective camera, and lit by a directional light source. Our method uses the MERL BRDF database to determine the optimal set of lightview pairs for data-driven reflectance acquisition. We develop a mathematical framework to estimate error from a given set of measurements, including the use of multiple measurements in an image simultaneously, as
needed for acquisition from near-field setups. The novel error metric is essential in the near-field case, where we show that using the condition-number alone performs poorly. We demonstrate practical near-field acquisition of BRDFs from only one or two input images. Our framework generalizes to configurations like a fixed camera setup, where we also develop a simple extension to spatially-varying BRDFs by clustering the materials.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of California
Authors: Xu, Z. (Ekstern), Nielsen, J. B. (Intern), Yu, J. (Ekstern), Jensen, H. W. (Ekstern), Ramamoorthi, R. (Ekstern)
Number of pages: 12
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**
Journal: ACM Transactions on Graphics
Volume: 35
Issue number: 6
Article number: 188
ISSN (Print): 0730-0301
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.69 SJR 2.45 SNIP 2.496
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.171 SNIP 3.744 CiteScore 6.24
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.098 SNIP 3.813 CiteScore 6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.381 SNIP 3.624 CiteScore 6.18
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.683 SNIP 4.089 CiteScore 4.77
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.857 SNIP 3.88 CiteScore 5.81
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.767 SNIP 4.03
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.294 SNIP 3.477
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.44 SNIP 3.427
Scopus rating (2007): SJR 2.16 SNIP 4.247
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.526 SNIP 4.444
Scopus rating (2005): SJR 1.141 SNIP 4.096
Scopus rating (2004): SJR 0.588 SNIP 3.226
Scopus rating (2003): SJR 0.833 SNIP 2.504
Scopus rating (2002): SJR 1.835 SNIP 2.213
Modelling of the Human Inner Ear Anatomy and Variability for Cochlear Implant Applications

This thesis takes the biomedical engineering approach to working with and understanding the anatomy and physiology of the inner ear. The purpose is to apply the acquired knowledge in the development of implantable hearing aids.

The so-called Cochlear Implant (CI) is a fascinating technology that without underselling it provides hearing for the deaf. The technology faces a number of challenges, and a part of the solution to those is closely connected with an improved understanding of the inner ear anatomy, both with regards to the individual patient but also to the variation in the population.

The inner ear is a relatively small structure and even with modern medical scanners only the coarsest details are revealed about the specific patient anatomy. To study the anatomy it is required to work on specimens from deceased subjects scanned with for instance μCT. The anatomy is complex and presents several challenges concerning data processing and analysis.

Our approach is to describe the inner ear as a statistical shape model. The thesis covers our work with regards to data segmentation, shape characterization, development of image registration model suited for the inner ear and construction of statistical deformation models.

The thesis results in a series of applications relating to CIs. The shape model can be used by CI-manufacturers for virtual product development and testing. At the same time, it can be applied to estimate the detailed inner ear shape from a clinical patient CT scan. This opens up for tools to optimize the programming of the CI, such that the hearing restoration is improved.

Monopolar Stimulation of the Implanted Cochlea: A Synthetic Population-Based Study

Cochlear implantation is carried out to recover the sense of hearing. However, its functional outcome varies highly between patients. In the current work, we present a study to assess the functional outcomes of cochlear implants considering the inter-variability found among a population of patients. In order to capture the cochlear anatomical details, a statistical shape model is created from high-resolution human μCT data. A population of virtual patients is automatically generated by sampling new anatomical instances from the statistical shape model. For each virtual patient, an implant insertion is simulated and a finite element model is generated to estimate the electrical field created into the cochlea. These simulations are defined according to the monopolar stimulation protocol of a cochlear implant and a prediction of
the voltage spread over the population of virtual patients is evaluated.

**General information**

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**Motion Tracking of Infants in Risk of Cerebral Palsy**

Every year 2-3 out of 1000 infants are born with cerebral palsy. Among others, the disorder often affects motor, cognitive and perceptual skills. The disorder is usually detected when the infants are old enough to crawl and walk, i.e. when the infant is 1-2 years old. However, studies show that the infant’s movements are affected already in the first year of life and methods exist for assessing the movements. The methods often require observation of the movements and qualitative evaluation of these. A more objective measure is desired in order to be able to diagnose cerebral palsy much earlier.

The goal with this thesis is to describe the development of a markerless motion tracking system for infants. Based on data recorded with a low-cost depth sensor, image analysis and mathematical modeling is used to model the infant’s body and its movements. Two methods are considered, where the first method is able to do single frame pose estimation, based on simple assumptions on the infant’s body. The second method uses an articulated model that incorporates anatomical constraints. Combining the two methods results in a robust motion tracking system for infants.

The results from the motion tracking are used to extract physical features such as velocity and acceleration of the individual body parts. A novel method for estimating scene flow in human motion data is presented, utilizing the results from the motion tracking. A number of examples are given for potential applications for automatic assessment of infant movement. This includes a preliminary study on automatic classification of movements related to cerebral palsy.

The contributions included in this thesis can be divided into two groups. The first two contributions consider the analysis in order to estimate and track the body of the infants. The remaining contributions consider different motion features derived from the motion tracking results. Both pose and motion features are extracted and used for assessing the infants’ motor development.

The presented work is a step closer to automatic motion assessment of infants with focus on early diagnosis of infants with cerebral palsy. Further collaboration with clinicians can result in breakthroughs in the way infants are monitored and assessed during the early years of life.

The main motivation is to be able to assess infants in risk of cerebral palsy based on the previously established connection between infant movement and brain injuries. However, as the data used in this study is recorded simultaneously with the study, the true outcome is not known. Even though some of the included infants were born preterm, none of them have to date been diagnosed with cerebral palsy.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Multi-region Statistical Shape Model for Cochlear Implantation

Statistical shape models are commonly used to analyze the variability between similar anatomical structures and their use is established as a tool for analysis and segmentation of medical images. However, using a global model to capture the variability of complex structures is not enough to achieve the best results. The complexity of a proper global model increases even more when the amount of data available is limited to a small number of datasets. Typically, the anatomical variability between structures is associated to the variability of their physiological regions. In this paper, a complete pipeline is proposed for building a multi-region statistical shape model to study the entire variability from locally identified physiological regions of the inner ear. The proposed model, which is based on an extension of the Point Distribution Model (PDM), is built for a training set of 17 high-resolution images (24.5 μm voxels) of the inner ear. The model is evaluated according to its generalization ability and specificity. The results are compared with the ones of a global model built directly using the standard PDM approach. The evaluation results suggest that better accuracy can be achieved using a regional modeling of the inner ear.

Multispectral UV imaging for fast and non-destructive quality control of chemical and physical tablet attributes

Monitoring of tablet quality attributes in direct vicinity of the production process requires analytical techniques that allow fast, non-destructive, and accurate tablet characterization. The overall objective of this study was to investigate the applicability of multispectral UV imaging as a reliable, rapid technique for estimation of the tablet API content and tablet hardness, as well as determination of tablet intactness and the tablet surface density profile. One of the aims was to establish an image analysis approach based on multivariate image analysis and pattern recognition to evaluate the potential of UV imaging for automatized quality control of tablets with respect to their intactness and surface density profile. Various tablets of different composition and different quality regarding their API content, radial tensile strength,
intactness, and surface density profile were prepared using an eccentric as well as a rotary tablet press at compression pressures from 20MPa up to 410MPa. It was found, that UV imaging can provide both, relevant information on chemical and physical tablet attributes. The tablet API content and radial tensile strength could be estimated by UV imaging combined with partial least squares analysis. Furthermore, an image analysis routine was developed and successfully applied to the UV images that provided qualitative information on physical tablet surface properties such as intactness and surface density profiles, as well as quantitative information on variations in the surface density. In conclusion, this study demonstrates that UV imaging combined with image analysis is an effective and non-destructive method to determine chemical and physical quality attributes of tablets and is a promising approach for (near) real-time monitoring of the tablet compaction process and formulation optimization purposes.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Hamburg, University of Copenhagen
Authors: Klukkert, M. (Ekstern), Wu, J. X. (Ekstern), Rantanen, J. (Ekstern), Carstensen, J. M. (Intern), Rades, T. (Ekstern), Leopold, C. S. (Ekstern)
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Web of Science (2016): Indexed yes
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BFI (2014): BFI-level 2
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Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 1.038 SNIP 1.287 CiteScore 3.47
ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 1.254 SNIP 1.425 CiteScore 3.6
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BFI (2011): BFI-level 2
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ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.169 SNIP 1.465
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.015 SNIP 1.265
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.927 SNIP 1.137
Scopus rating (2006): SJR 0.775 SNIP 1.039
Multispectral UV imaging for surface analysis of MUPS tablets with special focus on the pellet distribution

In the present study the applicability of multispectral UV imaging in combination with multivariate image analysis for surface evaluation of MUPS tablets was investigated with respect to the differentiation of the API pellets from the excipients matrix, estimation of the drug content as well as pellet distribution, and influence of the coating material and tablet thickness on the predictive model. Different formulations consisting of coated drug pellets with two coating polymers (Aquacoat® ECD and Eudragit® NE 30 D) at three coating levels each were compressed to MUPS tablets with various amounts of coated pellets and different tablet thicknesses. The coated drug pellets were clearly distinguishable from the excipients matrix using a partial least squares approach regardless of the coating layer thickness and coating material used. Furthermore, the number of the detected drug pellets on the tablet surface allowed an estimation of the true drug content in the respective MUPS tablet. In addition, the pellet distribution in the MUPS formulations could be estimated by UV image analysis of the tablet surface. In conclusion, this study revealed that UV imaging in combination with multivariate image analysis is a promising approach for the automatic quality control of MUPS tablets during the manufacturing process.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Hamburg, University of Copenhagen
Authors: Novikova, A. (Ekstern), Carstensen, J. M. (Intern), Rades, T. (Ekstern), Leopold, P. D. C. S. (Ekstern)
Pages: 374-383
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Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 1
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.297 SNIP 1.465 CiteScore 4.2
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.324 SNIP 1.555 CiteScore 4.13
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Non-destructive Quality control of tablets and blister packs by UV imaging

Quality control of tablets and its primary packing material within the manufacturing line requires analytical routines that allow monitoring of the desired product attributes with high efficiency. The aim of this study was to evaluate the suitability of multispectral UV imaging combined with multivariate image analysis for verification of blister pack filling, differentiation of tablets of varying composition therein, as well as detection of imprint defects and surface cracks of bulk tablets. Moreover, the influence of polymer sealing foils on tablet characterization within blister cavities was investigated. Several tablets of different composition were imaged either as bulk, within unsealed blister packs, or within blister packs that were manually sealed with three different types of either PVC or PCTFE foils. It was demonstrated that UV imaging is a fast and reliable technique for counting and differentiation of tablets within the blister packs. The sealing foils did not prevent characterization of the blister packs with regard to the tablets within the cavities. However, the polymer foils were found to cause changes in the multispectral UV image data set that allow to distinguish the blister packs based on the used polymer. Classification of the blister packs according to the composition of the tablets and the sealing foil was achieved. Furthermore, UV imaging was successfully applied to the detection of defects on imprinted codes and cracks on the surface of bulk tablets. Multispectral UV imaging is a powerful tool for quality control of tablets. Considering the highspeed of non-destructive image acquisition, this technique is promising for implementation in the tablet manufacturing process.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Hamburg, University of Copenhagen
Noninvasive particle sizing using camera-based diffuse reflectance spectroscopy

Diffuse reflectance measurements are useful for noninvasive inspection of optical properties such as reduced scattering and absorption coefficients. Spectroscopic analysis of these optical properties can be used for particle sizing. Systems based on optical fiber probes are commonly employed, but their low spatial resolution limits their validity ranges for the coefficients. To cover a wider range of coefficients, we use camera-based spectroscopic oblique incidence reflectometry. We develop a noninvasive technique for acquisition of apparent particle size distributions based on this approach. Our technique is validated using stable oil-in-water emulsions with a wide range of known particle size distributions. We also measure the apparent particle size distributions of complex dairy products. These results show that our tool, in contrast to those based on fiber probes, can deal with a range of optical properties wide enough to track apparent particle size distributions in a typical industrial process.
Novelty detection of foreign objects in food using multi-modal X-ray imaging

In this paper we demonstrate a method for novelty detection of foreign objects in food products using grating-based multimodal X-ray imaging. With this imaging technique three modalities are available with pixel correspondence, enhancing organic materials such as wood chips, insects and soft plastics not detectable by conventional X-ray absorption radiography. We conduct experiments, where several food products are imaged with common foreign objects typically found in the food processing industry. To evaluate the benefit from using this multi-contrast X-ray technique over conventional X-ray absorption imaging, a novelty detection scheme based on well known image- and statistical analysis techniques is proposed. The results show that the presented method gives superior recognition results and highlights the advantage of grating-based imaging.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Technische Universität München
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Scopus rating (2016): CiteScore 3.86 SJR 1.462 SNIP 1.719
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.509 SNIP 1.72 CiteScore 3.65
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Omnibus test for change detection in a time sequence of polarimetric SAR data

Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a (short) time series of multilook, polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change(s) occur. The technique is demonstrated on airborne EMISAR C-band data but may be applied to ALOS, COSMO-SkyMed, RadarSat-2, Sentinel-1, TerraSAR-X, and Yoagan or other dual- and quad/full-pol data also.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Skriver, H. (Intern)
On Practical Sampling of Bidirectional Reflectance

Accurate material models are a key part in producing convincing, photo-realistic, images in computer graphics. Elaborate analytical models exist, allowing graphics designers to manually design material appearance. However, given the complex nature and wide variability of material appearance, measuring this from the real world is an impractical and time-consuming process. Having a practical way of measuring material appearance will not only be of great value to the graphics community, but also open up for a wide range of new application areas, including industrial production quality control, digital prototyping and manufacturing, and interactive real-time product visualization.

In this thesis, the challenge of making material appearance measurements practical is addressed. Specifically, the Bidirectional Reflectance Distribution Function (BRDF), which is the quantity describing material appearance, is thoroughly analysed using both optimisation tools and multivariate statistics, in search of making BRDFs more accessible.

The work demonstrated includes an insight into the challenges of fitting analytical models to measured data and on the compromises one is bound to make when simplifying the real world with a parametric BRDF model. Specifically we identify what error measures work well for obtaining perceptually good results and how a simple BRDF model may be modified to better match real world data. With an offset in this, a linear, data-driven, BRDF model is proposed and a framework for reconstructing full and accurate BRDFs from only a few measurements is presented. It is here demonstrated that with as little as 20 point-samples, a BRDF can accurately be reconstructed. Furthermore utilising the field of view of a camera, this may be reduced to as little as two images. With this, the thesis demonstrates how BRDF measurements can be made practical, and it exemplifies this with a range of datasets intended for various purposes, each including high quality measured BRDFs.

Where the classical approach to BRDF capture may take weeks in measurement time, we here successfully demonstrate that is can in fact be reduced to no more than minutes or even seconds using our framework.
Precision and Accuracy Parameters in Structured Light 3-D Scanning

Structured light systems are popular in part because they can be constructed from off-the-shelf low cost components. In this paper we quantitatively show how common design parameters affect precision and accuracy in such systems, supplying a much needed guide for practitioners. Our quantitative measure is the established VDI/VDE 2634 (Part 2) guideline using precision made calibration artifacts. Experiments are performed on our own structured light setup, consisting of two cameras and a projector. We place our focus on the influence of calibration design parameters, the calibration procedure and encoding strategy and present our findings. Finally, we compare our setup to a state of the art metrology grade commercial scanner. Our results show that comparable, and in some cases better, results can be obtained using the parameter settings determined in this study.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Manufacturing Engineering
Authors: Eiríksson, E. R. (Intern), Wilm, J. (Intern), Pedersen, D. B. (Intern), Aanæs, H. (Intern)
Pages: 7-15
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Structured Light, 3d Scanning, Accuracy Assessment, VDI 2634 (2)
Electronic versions:
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10.5194/isprs-archives-XL-5-W8-7-2016

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Quantitative surface topography assessment of directly compressed and roller compacted tablet cores using photometric stereo image analysis
Surface topography, in the context of surface smoothness/roughness, was investigated by the use of an image analysis technique, MultiRay™, related to photometric stereo, on different tablet batches manufactured either by direct compression or roller compaction. In the present study, oblique illumination of the tablet (darkfield) was considered and the area of cracks and pores in the surface was used as a measure of tablet surface topography; the higher a value, the rougher the surface. The investigations demonstrated a high precision of the proposed technique, which was able to rapidly (within milliseconds) and quantitatively measure the obtained surface topography of the produced tablets. Compaction history, in the form of applied roll force and tablet punch pressure, was also reflected in the measured smoothness of the tablet surfaces. Generally it was found that a higher degree of plastic deformation of the microcrystalline cellulose resulted in a smoother tablet surface. This altogether demonstrated that the technique provides the pharmaceutical developer with a reliable, quantitative response parameter for visual appearance of solid dosage forms, which may be used for process and ultimately product optimization.

General information
State: Published
Authors: Allesø, M. (Ekstern), Carstensen, J. M. (Intern), Holm, P. (Ekstern), Holm, R. (Ekstern)
Surface topography, Surface roughness, Powder compaction, Roller compaction, Tablets, Microcrystalline cellulose, MultiRay™ image analysis

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Source: FindIt
Quantitative tumor heterogeneity assessment on a nuclear population basis

Immunohistochemistry (IHC) Ki-67 stain is widely used for visualizing cell proliferation. The common method for scoring the proliferation is to manually select and score a hot spot. This method is time-consuming and will often not give reproducible results due to subjective selection of the hotspots and subjective scoring. An automatic hotspot detection and proliferative index scoring would be time-saving, make the determination of the Ki-67 score easier and minimize the uncertainty of the score by introducing a more objective and standardized score.

Tissue Micro Array (TMA) cores stained for Ki-67 and their neighbor slide stained for Pan Cytokeratin (PCK) were aligned and Ki-67 positive and negative nuclei were identified inside tumor regions. A heatmap was calculated based on these and illustrates the distribution of the heterogenous response of Ki-67 positive nuclei in the tumor tissue. An automatic hot spot detection was developed and the Ki-67 score was calculated. All scores were compared with scores provided by a pathologist using linear regression models.

No significant difference was found between the Ki-67 scores guided by the developed heatmap and the scores provided by a pathologist. For comparison, scores were also calculated at a random place outside the hot spot and these scores were found to be significantly different from the pathologist scores.

A heatmap visualizing the heterogeneity in tumor tissue expressed by Ki-67 was developed and used for an automatic identification of hot spots in which a Ki-67 score was calculated. The Ki-67 scores did not differ significantly from scores provided by a pathologist.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Visiopharm, Aalborg University Hospital
Authors: Lindberg, A. W. (Intern), Conradsen, K. (Intern), Larsen, R. (Intern), Friis Lippert, M. (Ekstern), Røge, R. (Ekstern), Vyberg, M. (Forskerdatabase)
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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 2.48 SJR 1.372 SNIP 0.894
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Web of Science (2015): Indexed yes
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Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.49 SNIP 1.18 CiteScore 2.83
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 1.352 SNIP 1.198 CiteScore 2.8
ISI indexed (2012): ISI indexed yes
Scopus rating (2011): SJR 1.53 SNIP 1.141 CiteScore 3.09
ISI indexed (2011): ISI indexed yes
Scopus rating (2010): SJR 1.306 SNIP 1.058
Scopus rating (2009): SJR 1.044 SNIP 0.843
Web of Science (2009): Indexed yes
Scopus rating (2008): SJR 1.036 SNIP 0.968
Scopus rating (2007): SJR 1.172 SNIP 0.932
Scopus rating (2006): SJR 1.121 SNIP 0.986
Scopus rating (2005): SJR 0.929 SNIP 0.836
Scopus rating (2004): SJR 0.806 SNIP 0.597
Scopus rating (2003): SJR 0.111
Random walks with shape prior for cochlea segmentation in ex vivo μCT

Purpose

Cochlear implantation is a safe and effective surgical procedure to restore hearing in deaf patients. However, the level of restoration achieved may vary due to differences in anatomy, implant type and surgical access. In order to reduce the variability of the surgical outcomes, we previously proposed the use of a high-resolution model built from μCT images and then adapted to patient-specific clinical CT scans. As the accuracy of the model is dependent on the precision of the original segmentation, it is extremely important to have accurate μCT segmentation algorithms.

Methods

We propose a new framework for cochlea segmentation in ex vivo μCT images using random walks where a distance-based shape prior is combined with a region term estimated by a Gaussian mixture model. The prior is also weighted by a confidence map to adjust its influence according to the strength of the image contour. Random walks is performed iteratively, and the prior mask is aligned in every iteration.

Results

We tested the proposed approach in ten μCT data sets and compared it with other random walks-based segmentation techniques such as guided random walks (Eslami et al. in Med Image Anal 17(2):236–253, 2013) and constrained random walks (Li et al. in Advances in image and video technology. Springer, Berlin, pp 215–226, 2012). Our approach demonstrated higher accuracy results due to the probability density model constituted by the region term and shape prior information weighed by a confidence map.

Conclusion

The weighted combination of the distance-based shape prior with a region term into random walks provides accurate segmentations of the cochlea. The experiments suggest that the proposed approach is robust for cochlea segmentation.

General information

State: Published
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  BFI (2016): BFI-level 1
  Scopus rating (2016): CiteScore 1.76 SJR 0.522 SNIP 1.291
  Web of Science (2016): Indexed yes
  BFI (2015): BFI-level 1
Rapid Assessment of Tablet Film Coating Quality by Multispectral UV Imaging

Chemical imaging techniques are beneficial for control of tablet coating layer quality as they provide spectral and spatial information and allow characterization of various types of coating defects. The purpose of this study was to assess the applicability of multispectral UV imaging for assessment of the coating layer quality of tablets. UV images were used to detect, characterize, and localize coating layer defects such as chipped parts, inhomogeneities, and cracks, as well as to evaluate the coating surface texture. Acetylsalicylic acid tablets were prepared on a rotary tablet press and coated with a polyvinyl alcohol-polyethylene glycol graft copolymer using a pan coater. It was demonstrated that the coating intactness can be assessed accurately and fast by UV imaging. The different types of coating defects could be differentiated and localized based on multivariate image analysis and Soft Independent Modeling by Class Analogy applied to the UV images. Tablets with inhomogeneous texture of the coating could be identified and distinguished from those with a homogeneous surface texture. Consequently, UV imaging was shown to be well-suited for monitoring of the tablet coating layer quality. UV imaging is a promising technique for fast quality control of the tablet coating because of the high data acquisition speed and its nondestructive analytical nature.
Rationalization with ruled surfaces in architecture
This thesis addresses the problems of rationalizing and segmenting large scale 3D models, and how to handle difficult production constraints in this area. The design choices when constructing large scale architecture are influenced by the budget. Therefore I strive to minimize the amount of time and material needed for production. This makes advanced free form architecture viable for low cost projects, allowing the architects to realize their designs.

By pre-cutting building blocks using hot wire robots, the amount of milling necessary can be reduced drastically. I do this by rationalizing the intended shape as a piecewise ruled surface; the developed method was able to cut away up to 95% of the excess material. Methods were developed to minimize the number of blocks necessary to build advanced large scale 3D shapes. Using stochastic optimization to guide the segmentation, it was possible to remove up to 48% of the building blocks. Hot blade cutting for constructing models with positive Gauss curvature is an upcoming technology. Three segmentation algorithms were developed to solve construction constraints that arises when using this technique. One of the algorithms focuses on creating an aesthetic segmentation.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Mathematics
Authors: Steenstrup, K. H. (Intern), Gravesen, J. (Intern), Bærentzen, J. A. (Intern)
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Series: DTU Compute PHD-2016
Number: 413
Real Time Structured Light and Applications
Structured light scanning is a versatile method for 3D shape acquisition. While much faster than most competing measurement techniques, most high-end structured light scans still take in the order of seconds to complete.

Low-cost sensors such as Microsoft Kinect and time of flight cameras have made 3D sensor ubiquitous and have resulted in a vast amount of new applications and methods. However, such low-cost sensors are generally limited in their accuracy and precision, making them unsuitable for e.g. accurate tracking and pose estimation.

With recent improvements in projector technology, increased processing power, and methods presented in this thesis, it is possible to perform structured light scans in real time with 20 depth measurements per second. This offers new opportunities for studying dynamic scenes, quality control, human-computer interaction and more.

This thesis discusses several aspects of real time structured light systems and presents contributions within calibration, scene coding and motion correction aspects. The problem of reliable and fast calibration of such systems is addressed with a novel calibration scheme utilising radial basis functions [Contribution B]. A high performance flexible open source software toolkit is presented [Contribution C], which makes real time scanning possible on commodity hardware. Further, an approach is presented to correct for motion artifacts in dynamic scenes [Contribution E].

An application for such systems is presented with a head tracking approach for medical motion correction [Contribution A, F]. This aims to solve the important problem of motion artifacts, which occur due to head movement during long acquisition times in MRI and PET scans. In contrast to existing methods, the one presented here is MRI compatible [Contribution D], not dependent on fiducial markers, and suitable for prospective correction.

Factors contributing to accuracy and precision of structured light systems are investigated with a study of performance factors [Contribution G]. This is also done in the context of biological tissue, which exhibit subsurface effects and other undesirable effects [Contribution H], and it is shown that this error is to a large extent deterministic and can be corrected.

Regional Hippocampal Atrophy and Higher Levels of Plasma Amyloid-Beta Are Associated With Subjective Memory Complaints in Nondemented Elderly Subjects
Background: Evidence suggests a link between the presence of subjective memory complaints (SMC) and lower volume of the hippocampus, one of the first regions to show neuropathological lesions in Alzheimer's disease. However, it remains unknown whether this pattern of hippocampal atrophy is regionally specific and whether SMC are also paralleled by changes in peripheral levels of amyloid-beta (Aβ).
Methods: The volume of hippocampal subregions and plasma Aβ levels were cross-sectionally compared between elderly individuals with (SMC(+); N = 47) and without SMC (SMC(-); N = 48). Significant volume differences in hippocampal subregions were further correlated with plasma Aβ levels and with objective memory performance.

Results: Individuals with SMC exhibited significantly higher Aβ1-42 concentrations and lower volumes of CA1, CA4, dentate gyrus, and molecular layer compared with SMC(-) participants. Regression analyses further showed significant associations between lower volume of the dentate gyrus and both poorer memory performance and higher plasma Aβ1-42 levels in SMC(+) participants.

Conclusions: The presence of SMC, lower volumes of specific hippocampal regions, and higher plasma Aβ1-42 levels could be conditions associated with aging vulnerability. If such associations are confirmed in longitudinal studies, the combination may be markers recommending clinical follow-up in nondemented older adults.

General information
State: Published
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Photogrammetric measurements of bodily dimensions and analysis of gait patterns in CCTV are important tools in forensic investigations but accurate extraction of the measurements are challenging. This study tested whether manual annotation of the joint centers on 3D reconstructions could provide reliable recognition. Sixteen participants performed normal walking where 3D reconstructions were obtained continually. Segment lengths and kinematics from the extremities were manually extracted by eight expert observers. The results showed that all the participants were recognized, assuming the same expert annotated the data. Recognition based on data annotated by different experts was less reliable achieving 72.6% correct recognitions as some parameters were heavily affected by interobserver variability. This study verified that 3D reconstructions are feasible for forensic gait analysis as an improved alternative to conventional CCTV. However, further studies are needed to account for the use of different clothing, field conditions, etc.
Robotic Hot-Blade Cutting: An Industrial Approach to Cost-Effective Production of Double Curved Concrete Structures

This paper presents a novel method for cost-effective, robotic production of double curved formwork in Expanded Polystyrene (EPS) for in situ and prefabricated concrete construction. A rationalization and segmentation procedure is developed, which allows for the transliteration of double curved NURBS surfaces to Euler elastica surface segments, while respecting various constraints of production. An 18 axis, tri-robot system approximates double curved NURBS surfaces by means of an elastically deformed and heated blade, mounted on the flanges of two manipulators. Re-orienting or translating either end of the blade dynamically deforms the blade’s curvature. The blade follows the contours of the rationalized surface by continuous change in position and orientation of the end-effectors. The concept’s potential is studied by a pilot production of a full-scale demonstrator panel assembly.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Mathematics, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Manufacturing Engineering, Odico Formwork Robotics Aps, GXN A/S, Danish Technological Institute
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Segmentation of individual fibres in a uni-directional composite from 3D X-ray computed tomography data

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Short-Term Change Detection in Wetlands Using Sentinel-1 Time Series
Automated monitoring systems that can capture wetlands' high spatial and temporal variability are essential for their management. SAR-based change detection approaches offer a great opportunity to enhance our understanding of complex and dynamic ecosystems. We test a recently-developed time series change detection approach (S1-omnibus) using Sentinel-1 imagery of two wetlands with different ecological characteristics; a seasonal isolated wetland in southern Spain and a coastal wetland in the south of France. We test the S1-omnibus method against a commonly-used pairwise comparison of consecutive images to demonstrate its advantages. Additionally, we compare it with a pairwise change detection method using a subset of consecutive Landsat images for the same period of time. The results show how S1-omnibus is capable of capturing in space and time changes produced by water surface dynamics, as well as by agricultural practices, whether they are sudden changes, as well as gradual. S1-omnibus is capable of detecting a wider array of short-term changes than when using consecutive pairs of Sentinel-1 images. When compared to the Landsat-based change detection method, both show an overall good agreement, although certain landscape changes are detected only by either the Landsat-based or the S1-omnibus method. The S1-omnibus method shows a great potential for an automated monitoring of short time changes and accurate delineation of areas of high variability and of slow and gradual changes.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing, University of Bonn, Jena Optronik GMBH
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Simultaneous Reconstruction and Segmentation with Class-Specific Priors

Studying the interior of objects using tomography often require an image segmentation, such that different material properties can be quantified. This can for example be volume or surface area. Segmentation is typically done as an image analysis step after the image has been reconstructed. This thesis investigates computing the reconstruction and segmentation simultaneously. The advantage of this is that because the reconstruction and segmentation are computed jointly, reconstruction errors are not propagated to the segmentation step. Furthermore the segmentation procedure can be used for regularizing the reconstruction process. The thesis provides models and algorithms for simultaneous reconstruction and segmentation and their performance is empirically validated.

Two method of simultaneous reconstruction and segmentation are described in the thesis. Also, a method for parameter selection is given. The reconstruction and segmentation are modeled as two parts: the image that is reconstructed and a so-called Hidden Markov Measure Field Model (HMMFM). Pixel values in the image contain material attenuation coefficients and the HMMFM contains pixelwise probabilities for material classes. The number of material classes and their parameters are assumed known a priori. These parameters are the mean value of the class attenuation coefficients and their standard deviations. Given this input together with projection data, the problem is to find the image and HMMFM. The segmentation is obtained from the HMMFM as the most probable class in each pixel.

The solution for the reconstruction and segmentation problem is found using an algorithm that simultaneously minimizes the reprojection error, deviation of the grey levels of pixels from known mean values and the spatial differences in the class probabilities.

In the first Simultaneous Reconstruction and Segmentation (SRS) method data is assumed Gaussian distributed and the minimization is done using standard optimization techniques in two stages. Experimental validation on both phantom and real data shows that modeling the reconstruction and segmentation simultaneously has superior performance, especially when the problem is underdetermined, i.e. when the number of unknowns in the reconstruction exceeds the number of observations.

The second SRS method assumes Poisson distributed data, which is the case for data originating from discrete events like photon counts. The algorithm is again based on solving a minimization problem. In addition a relaxation strategy is employed in order to avoid being stuck in local minimum. This model is also validated on artificial data.

Selecting appropriate regularization parameters can be difficult, so the last thing that we consider is a parameter selection approach. The most promising approach was a modified L-curve algorithm, which was empirically analyzed.

This thesis contributes with methods for simultaneous reconstruction and segmentation and demonstrates the benefits of this approach in situations where only few projections are available and data is noisy. Here a higher precision image as well as segmentation can be computed.

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Authors: Romanov, M. (Intern), Dahl, A. B. (Intern), Hansen, P. C. (Intern)
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Simultaneous Whole-Brain Segmentation and White Matter Lesion Detection Using Contrast-Adaptive Probabilistic Models

In this paper we propose a new generative model for simultaneous brain parcellation and white matter lesion segmentation from multi-contrast magnetic resonance images. The method combines an existing whole-brain segmentation technique with a novel spatial lesion model based on a convolutional restricted Boltzmann machine. Unlike current state-of-the-art lesion detection techniques based on discriminative modeling, the proposed method is not tuned to one specific scanner or imaging protocol, and simultaneously segments dozens of neuroanatomical structures. Experiments on a public benchmark dataset in multiple sclerosis indicate that the method’s lesion segmentation accuracy compares well to that of the current state-of-the-art in the field, while additionally providing robust whole-brain segmentations.

Single-Shot-RARE for rapid 3D hyperpolarized metabolic ex vivo tissue imaging: RF-pulse design for semi-dense spectra

MRS of hyperpolarized (HP) 13C-enriched compounds is a promising method for in vivo cancer diagnosis. Sentinel lymph node ex vivo tissue sample histology used in clinical routine for breast cancer metastasis diagnosis requires time consuming sample analysis. 3D-HP-MRSI can potentially speed up the diagnosis given a sensitive marker that can be efficiently imaged in tissue after homogenous injection. The entire sample can be confined within the imaged volume giving the possibility of complete spatial non-selectivity of the radio frequency (RF) pulses in the RF pulse design with no chemical shift localization errors. Since only a few product signals are of interest for this application, a combination of under-sampled temporal encoding, frequency selective excitation and the Single-Shot-RAREsequence offers favourable SNR characteristics. Small peak separations are challenging, however, since they require narrow excitation transition-bands. We have designed a 3D-MRSI pulse sequence for hyperpolarized ex vivo sample imaging for semi-dense compound spectra (few components, relatively small separations), ultimately aimed to be used for metastasis detection in excised lymph nodes.
Stable reconstruction of Arctic sea level for the 1950-2010 period

Reconstruction of historical Arctic sea level is generally difficult due to the limited coverage and quality of both tide gauge and altimetry data in the area. Here a strategy to achieve a stable and plausible reconstruction of Arctic sea level from 1950 to today is presented. This work is based on the combination of tide gauge records and a new 20-year reprocessed satellite altimetry derived sea level pattern. Hence the study is limited to the area covered by satellite altimetry (68ºN and 82ºN). It is found that timestep cumulative reconstruction as suggested by Church and White (2000) may yield widely variable results and is difficult to stabilize due to the many gaps in both tide gauge and satellite data. A more robust sea level reconstruction approach is to use datum adjustment of the tide gauges in combination with satellite altimetry, as described by (Ray and Douglas, 2011). In this approach, a datum-fit of each tide gauges is used and the method takes into account the entirety of each tide gauge record. This makes the Arctic sea level reconstruction much less prone to drifting. From our reconstruction, we found that the Arctic mean sea level trend is around 1.5 mm +/- 0.3 mm/y for the period 1950 to 2010, between 68ºN and 82ºN. This value is in good agreement with the global mean trend of 1.8 +/- 0.3 mm/y over the same period as found by Church and White (2004).

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Statistical shape model with random walks for inner ear segmentation

Cochlear implants can restore hearing to completely or partially deaf patients. The intervention planning can be aided by providing a patient-specific model of the inner ear. Such a model has to be built from high resolution images with accurate segmentations. Thus, a precise segmentation is required. We propose a new framework for segmentation of micro-CT cochlear images using random walks combined with a statistical shape model (SSM). The SSM allows us to constrain the less contrasted areas and ensures valid inner ear shape outputs. Additionally, a topology preservation method is proposed to avoid the leakage in the regions with no contrast.

Tangible 3D modeling of coherent and themed structures

We present CubeBuilder, a system for interactive, tangible 3D shape modeling. CubeBuilder allows the user to create a digital 3D model by placing physical, non-interlocking cubic blocks. These blocks may be placed in a completely arbitrary fashion and combined with other objects. In effect, this turns the task of 3D modeling into a playful activity that hardly requires any learning on the part of the user. The blocks are registered using a depth camera and entered into the cube graph where each block is a node and adjacent blocks are connected by edges. From the cube graph, we transform the initial cubes into coherent structures by generating smooth connection geometry for some edges of the graph. Based on an analysis of the cube graph, we identify subgraphs that match given graph templates. These subgraph templates map to predefined geometric refinements of the basic shape. This, in turn, allows the user to tangibly build structures of greater details than the blocks provide in and of themselves. We show a number of shapes that have been modeled by users and are indicative of the expressive power of the system. Furthermore, we demonstrate the scalability of the tangible interface which appears to be limited only by the number of blocks available.
The Traveling Optical Scanner – Case Study on 3D Shape Models of Ancient Brazilian Skulls

Recovering detailed morphological information from archaeological or paleontological material requires extensive hands-on time. Creating 3D scans based on e.g. computed tomography (CT) will recover the geometry of the specimen, but can inflict bimolecular degradation. Instead, we propose a fast, inoffensive and inexpensive 3D scanning modality based on structured light, suitable for capturing the morphology and the appearance of specimens. Benefits of having 3D models are manifold. The 3D models are easy to share among researchers and can be made available to the general public. Advanced morphological modelling is possible with accurate description of the specimens provided by the models.
Furthermore, performing studies on models reduces the risk of damage to the original specimen. In our work we employ a high resolution structured light scanner for digitalizing a collection of 8500 year old human skulls from Brazil. To evaluate the precision of our setup we compare the structured light scan to micro-CT and achieve submillimetre difference. We analyse morphological features of the Brazilian skulls using manual landmarks, but a research goal is to automate this, fully utilize the dense 3D scans, and apply the method to many more samples.

**Training Convolutional Neural Networks for Translational Invariance on SAR ATR**

In this paper we present a comparison of the robustness of Convolutional Neural Networks (CNN) to other classifiers in the presence of uncertainty of the objects localization in SAR image. We present a framework for simulating simple SAR images, translating the object of interest systematically and testing the classification performance. Our results show that where other classification methods are very sensitive to even small translations, CNN is quite robust to translational variance, making it much more useful in relation to Automatic Target Recognition (ATR) in a real life context.

**Tunnel Effect in CNNs: Image Reconstruction From Max-Switch Locations**

In this paper, we show that reconstruction of an image passed through a neural network is possible, using only the locations of the max pool activations. This was demonstrated with an architecture consisting of an encoder and a decoder.
The decoder is a mirrored version of the encoder, where convolutions are replaced with deconvolutions and poolings are replaced with unpooling layers. The locations of the max pool switches are transmitted to the corresponding unpooling layer. The reconstruction is computed only from these switches without the use of feature values. Using only the max switch location information of the pool layers, a surprisingly good image reconstruction can be achieved. We examine this effect in various architectures, as well as how the quality of the reconstruction is affected by the number of features. We also compare the reconstruction with an encoder with randomly initialized weights with an encoder pretrained for classification. Finally, we give recommendations for future architecture decisions.
Using Diffusion Tractography to Predict Cortical Connection Strength and Distance: A Quantitative Comparison with Tracers in the Monkey

Tractography based on diffusion MRI offers the promise of characterizing many aspects of long-distance connectivity in the brain, but requires quantitative validation to assess its strengths and limitations. Here, we evaluate tractography's ability to estimate the presence and strength of connections between areas of macaque neocortex by comparing its results with published data from retrograde tracer injections. Probabilistic tractography was performed on high-quality postmortem diffusion imaging scans from two Old World monkey brains. Tractography connection weights were estimated using a fractional scaling method based on normalized streamline density. We found a correlation between log-transformed tractography and tracer connection weights of $r = 0.59$, twice that reported in a recent study on the macaque. Using a novel method to estimate interareal connection lengths from tractography streamlines, we regressed out the distance dependence of connection strength and found that the correlation between tractography and tracers remains positive, albeit substantially reduced. Altogether, these observations provide a valuable, data-driven perspective on both the strengths and limitations of tractography for analyzing interareal corticocortical connectivity in nonhuman primates and a framework for assessing future tractography methodological refinements objectively.

SIGNIFICANCE STATEMENT Tractography based on diffusion MRI has great potential for a variety of applications, including estimation of comprehensive maps of neural connections in the brain ("connectomes"). Here, we describe methods to assess quantitatively tractography's performance in detecting interareal cortical connections and estimating connection strength by comparing it against published results using neuroanatomical tracers. We found the correlation of tractography's estimated connection strengths versus tracer to be twice that of a previous study. Using a novel method for calculating interareal cortical distances, we show that tractography-based estimates of connection strength have useful predictive power beyond just interareal separation. By freely sharing these methods and datasets, we provide a valuable resource for future studies in cortical connectomics.
This is a study of a uni-directional non-crimp fabric reinforced epoxy composite material typically used as the load carrying laminate in wind turbine blades. Based on a 3D xray tomography scan, the bundle and fibre/matrix structure of the composite is segmented. This segmentation is used in a multi-scale finite element model bridging the gap from the individual fibers organized in bundles to the stitched non-crimp fabric used for building up the load carrying laminates.
Method for Surface Scanning in Medical Imaging and Related Apparatus

A method and apparatus for surface scanning in medical imaging is provided. The surface scanning apparatus comprises an image source, a first optical fiber bundle comprising first optical fibers having proximal ends and distal ends, and a first optical coupler for coupling an image from the image source into the proximal ends of the first optical fibers, wherein the first optical coupler comprises a plurality of lens elements including a first lens element and a second lens element, each of the plurality of lens elements comprising a primary surface facing a distal end of the first optical coupler, and a secondary surface facing a proximal end of the first optical coupler.

3D interactive topology optimization on hand-held devices

This educational paper describes the implementation aspects, user interface design considerations and workflow potential of the recently published TopOpt 3D App. The app solves the standard minimum compliance problem in 3D and allows the user to change design settings interactively at any point in time during the optimization. Apart from its educational nature, the app may point towards future ways of performing industrial design. Instead of the usual geometrize, then model and optimize approach, the geometry now automatically adapts to the varying boundary and loading conditions. The app is freely available for iOS at Apple’s App Store and at http://www.topopt.dtu.dk/TopOpt3D for Windows and OSX.
4-D PET-MR with Volumetric Navigators and Compressed Sensing

Hybrid PET-MR scanners acquire multi-modal signals simultaneously, eliminating the requirement of software alignment between the MR and PET imaging data. However, the acquisition of high-resolution MR and PET images requires long scanning times, therefore movement of the subject during the acquisition deteriorates both the PET and the MR images. In this work we have developed an approach for tightly integrated PET-MR imaging, making use of volumetric MR navigators to inform, in real-time, both the MR acquisition and the PET reconstruction. The integrated imaging procedure that we describe exploits the simultaneity of MR and PET in hybrid PET-MR systems, producing inherently-aligned motion-free MR and PET images. We describe the system setup, the algorithm for motion-corrected reconstruction, an adaptive sinogram binning algorithm and software design decisions aimed at integrating tightly the MR and PET subsystems. Application of the integrated motion-corrected acquisition procedure to a phantom study and to a volunteer subject demonstrates the validity of the approach for a variety of motion patterns.

General information

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60-year Nordic and arctic sea level reconstruction based on a reprocessed two decade altimetric sea level record and tide gauges

Due to the sparsity and often poor quality of data, reconstructing Arctic sea level is highly challenging. We present a reconstruction of Arctic sea level covering 1950 to 2010, using the approaches from Church et al. (2004) and Ray and Douglas (2011). This involves decomposition of an altimetry calibration record into EOFs, and fitting these patterns to a historical tide gauge record.

General information

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Accuracy in Robot Generated Image Data Sets
In this paper we present a practical innovation concerning how to achieve high accuracy of camera positioning, when using a 6 axis industrial robots to generate high quality data sets for computer vision. This innovation is based on the realization that to a very large extent the robots positioning error is deterministic, and can as such be calibrated away. We have successfully used this innovation in our efforts for creating data sets for computer vision. Since the use of this innovation has a significant effect on the data set quality, we here present it in some detail, to better aid others in using robots for image data set generation.

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A computational atlas of the hippocampal formation using ex vivo, ultra-high resolution MRI: Application to adaptive segmentation of in vivo MRI.
Automated analysis of MRI data of the subregions of the hippocampus requires computational atlases built at a higher resolution than those that are typically used in current neuroimaging studies. Here we describe the construction of a statistical atlas of the hippocampal formation at the subregion level using ultra-high resolution, ex vivo MRI. Fifteen autopsy samples were scanned at 0.13 mm isotropic resolution (on average) using customized hardware. The images were manually segmented into 13 different hippocampal substructures using a protocol specifically designed for this study; precise delineations were made possible by the extraordinary resolution of the scans. In addition to the subregions, manual annotations for neighboring structures (e.g., amygdala, cortex) were obtained from a separate dataset of in vivo, T1-weighted MRI scans of the whole brain (1 mm resolution). The manual labels from the in vivo and ex vivo data were combined into a single computational atlas of the hippocampal formation with a novel atlas building algorithm based on Bayesian inference. The resulting atlas can be used to automatically segment the hippocampal subregions in structural MRI images, using an algorithm that can analyze multimodal data and adapt to variations in MRI contrast due to differences in acquisition hardware or pulse sequences. The applicability of the atlas, which we are releasing as part of FreeSurfer (version 6.0), is demonstrated with experiments on three different publicly available datasets with different types of MRI contrast. The results show that the atlas and companion segmentation method: 1) can segment T1 and T2 images, as well as their combination, 2) replicate findings on mild cognitive impairment based on high-resolution T2 data, and 3) can discriminate between Alzheimer's disease subjects and elderly controls with 88% accuracy in standard resolution (1 mm) T1 data, significantly outperforming the atlas in FreeSurfer version 5.3 (86% accuracy) and classification based on whole hippocampal volume (82% accuracy).

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School, Aalto University, Boston University, Massachusetts Institute of Technology
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Pages: 117-137
Publication date: 2015
An algorithm for optimal fusion of atlases with different labeling protocols

In this paper we present a novel label fusion algorithm suited for scenarios in which different manual delineation protocols with potentially disparate structures have been used to annotate the training scans (hereafter referred to as “atlases”). Such scenarios arise when atlases have missing structures, when they have been labeled with different levels of detail, or when they have been taken from different heterogeneous databases. The proposed algorithm can be used to automatically label a novel scan with any of the protocols from the training data. Further, it enables us to generate new labels that are not present in any delineation protocol by defining intersections on the underlying labels. We first use probabilistic models of label fusion to generalize three popular label fusion techniques to the multi-protocol setting: majority voting, semi-locally weighted voting and STAPLE. Then, we identify some shortcomings of the generalized methods, namely the inability to produce meaningful posterior probabilities for the different labels (majority voting, semi-locally weighted voting) and to exploit the similarities between the atlases (all three methods). Finally, we propose a novel generative label fusion model that can overcome these drawbacks. We use the proposed method to combine four brain MRI datasets labeled with different protocols (with a total of 102 unique labeled structures) to produce segmentations of 148 brain regions. Using cross-validation, we show that the proposed algorithm outperforms the generalizations of majority voting, semi-locally weighted voting and STAPLE (mean Dice score 83%, vs. 77%, 80% and 79%, respectively). We also evaluated the proposed algorithm in an aging study, successfully reproducing some well-known results in cortical and subcortical structures. (C) 2014 The Authors. Published by Elsevier Inc.
Anatomically Correct Surface Recovery: A Statistical Approach

We present a method for 3D surface recovery in partial surface scans. The method is based on an Active Shape Model, which is used to predict missing data. The model is constructed using a bootstrap framework, where an initially small collection of hand-annotated samples is used to fit to and register unknown samples, resulting in an extensive statistical model. The statistical recovery uses a multivariate point prediction, where the distribution of the points is given by the Active Shape Model. We show how missing data in a partial scan, once point correspondence is achieved, can be predicted using the learned statistics. A quantitative evaluation is performed on a data set of 10 laser scans of ear canal impressions with minimal noise and artificial holes. We also present a qualitative evaluation on authentic partial scans from an actual direct in ear scanner prototype. Compared to a state-of-the-art surface reconstruction algorithm, the presented method gives matching prediction results for the synthetic evaluation samples and superior results for the direct scanner data.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Jensen, R. R. (Intern), Nielsen, J. B. (Intern), Larsen, R. (Intern), Paulsen, R. R. (Intern)
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

An Ensemble of 2D Convolutional Neural Networks for Tumor Segmentation

Accurate tumor segmentation plays an important role in radiosurgery planning and the assessment of radiotherapy treatment efficacy. In this paper we propose a method combining an ensemble of 2D convolutional neural networks for doing a volumetric segmentation of magnetic resonance images. The segmentation is done in three steps; first the full tumor region, is segmented from the background by a voxel-wise merging of the decisions of three networks learned from three orthogonal planes, next the segmentation is refined using a cellular automaton-based seed growing method known as growcut. Finally, within-tumor sub-regions are segmented using an additional ensemble of networks trained for the task. We demonstrate the method on the MICCAI Brain Tumor Segmentation Challenge dataset of 2014, and show improved segmentation accuracy compared to an axially trained 2D network and an ensemble segmentation without growcut. We further obtain competitive Dice scores compared with the most recent tumor segmentation challenge.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
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Main Research Area: Technical/natural sciences
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Tumor segmentation, Convolutional neural network, Ensemble classification, Cellular automaton
A new self-made digital slide scanner and microscope for imaging and quantification of fluorescent microspheres

Objective: A low-cost microscope slide scanner was constructed for the purpose of digital imaging of newborn piglet brain tissue and to quantify fluorescent microspheres in tissue. Methods: Using a standard digital single-lens reflex (DSLR) camera, fluorescent imaging of newborn piglet brain tissue was performed. A computer algorithm available for download was created to detect fluorescent microspheres in the brain tissue slides and to calculate regional cerebral blood flow (rCBF). The precision of the algorithm was tested by comparing with manual counting of the fluorescent microspheres. Finally, bright-field imaging was tested by adding light diffuser film. Results: Cost of the slide scanner was a fraction of the cost of a commercial slide scanner. The slide scanner was able to image a large number of tissue slides in a semiautomatic manner and provided a large field of view (FOV) of 101 mm² combined with a resolution of 2.9 µm. The mean difference (SD) between manual and automatic counts was in absolute numbers 0.32 (1.5) microspheres ranging from -5 to 5 microspheres per slide. The relative total difference between automatic and manual counts was -3.1%. Conclusions: A slide scanner was constructed and an automatic algorithm to detect fluorescent microspheres in tissue was developed and validated and showed an acceptable difference to “gold standard” manual counting. The slide scanner can be regarded as a low-cost alternative for researchers when digital slide imaging and quantification of fluorescent microspheres are needed.

General information
State: Published
Organisations: Department of Photonics Engineering, Diode Lasers and LED Systems, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen, Copenhagen University Hospital
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Pages: 33-39
Publication date: 2015
Main Research Area: Technical/natural sciences

An MRI Compatible Surface Scanner

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital, Massachusetts General Hospital
Authors: Olesen, O. V. (Intern), Wilm, J. (Intern), Van der Kouwe, A. (Ekstern), Jensen, R. R. (Intern), Larsen, R. (Intern), Wald, L. L. (Ekstern)
Publication date: 2015
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Main Research Area: Technical/natural sciences
A Parameter Choice Method for Simultaneous Reconstruction and Segmentation

The problem of finding good regularization parameters for the reconstruction problems without knowledge of the ground truth is a non-trivial task. We overview the existing parameter choice methods and present the modified L-curves approach for a good regularization parameters selection that is suited for our Simultaneous Reconstruction and Segmentation method. We verify the validity of this approach with numerical experiments based on reconstructions of artificial phantoms from noisy data, and the problems in our numerical experiments are underdetermined.

Arctic Sea Level Change over the altimetry era and reconstructed over the last 60 years

The Arctic Ocean process severe limitations on the use of altimetry and tide gauge data for sea level studies and prediction due to the presence of seasonal or permanent sea ice. In order to overcome this issue we reprocessed all altimetry data with editing tailored to Arctic conditions, hereby more than doubling the amount of altimetry in the Arctic Ocean with up to 10 times the amount of data in regions like the Beaufort Gyre region compared with AVISO and RADS datasets. With recent data from the Cryosat-2 SAR altimetry the time-series now runs from 1991-2015 a total of nearly 25 years.

Good altimetric data is seen to crucial for sea level studies and profoundly for sea level reconstruction where we present a 60 years sea level reconstruction based on this new data set. We here present a new multi-decade altimetric dataset and a 60 year reconstruction of sea level based on this together with tide gauge information. From our reconstruction, we found that the Arctic mean sea level trend is around 1.5 mm +/- 0.3 mm/y for the period 1950 to 2010, between 68ºN and 82ºN. This value is in good agreement with the global mean trend of 1.8 +/- 0.3 mm/y over the same period as found by Church and White (2004). We also find significant higher trend in the Beaufort Gyre region showing an increase in sea level over the last decade up to 2011.
Assisting doctors on assessing movements in infants using motion tracking
In this work, we consider the possibilities of having an automatic computer-based system for tracking the movements of infants. An existing motion tracking system is used to process recorded video sequences containing both color and spatial information of the infant's body pose and movements. The system uses these sequences of data to estimate the underlying skeleton of the infant and parametrize the movements. Post-processing of these parameters can yield objective measurements of an infant's movement patterns. This could e.g. be quantification of (a)symmetry and recognition of certain gestures/actions such as kicking, crying, roll over and bringing hands together. Clinicians could benefit from such a system, as it would ease the task of diagnosing infants with motor disorders, and in some cases, this could initiate an intervention earlier than usual. It should be clear, that we do not seek to substitute the task of the clinicians, but the system should instead be considered as a tool for easy extraction of objective measurements describing the movements and as well as a screening tool for highlighting certain patterns in the movements.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Olsen, M. (Ekstern), Herskind, A. (Ekstern), Nielsen, J. B. (Ekstern), Paulsen, R. R. (Intern)
Number of pages: 1
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.23 SJR 1.535 SNIP 1.536
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.681 SNIP 1.727 CiteScore 2.26
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.725 SNIP 1.732 CiteScore 2.24
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.56 SNIP 1.826 CiteScore 2.27
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.469 SNIP 1.471 CiteScore 2.06
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.29 SNIP 1.614 CiteScore 2.16
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.637 SNIP 1.893
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.559 SNIP 1.636
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.485 SNIP 1.565
Scopus rating (2007): SJR 1.313 SNIP 1.612
Scopus rating (2006): SJR 1.136 SNIP 1.535
Scopus rating (2005): SJR 1.022 SNIP 1.464
Scopus rating (2004): SJR 1.356 SNIP 1.435
Scopus rating (2003): SJR 0.945 SNIP 1.432
Automatic Generation of a Computational Model for Monopolar Stimulation of Cochlear Implants

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen Center for Health Technology, Universitat Pompeu Fabra, INRIA Sophia Antipolis, Alma Medical Systems, MED-EL GMBH
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Pages: S67-S68
Publication date: 2015
Conference: 29th International Congress on Computer Assisted Radiology and Surgery (CARS 2015), Barcelona, Spain, 24/06/2015 - 24/06/2015
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 1.76 SJR 0.522 SNIP 1.291
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.481 SNIP 1.108 CiteScore 1.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.486 SNIP 1.301 CiteScore 1.79
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.551 SNIP 1.217 CiteScore 1.85
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.417 SNIP 1.099 CiteScore 1.63
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.346 SNIP 0.984 CiteScore 1.4
Scopus rating (2010): SJR 0.313 SNIP 0.792
Scopus rating (2009): SJR 0.178 SNIP 0.295
Scopus rating (2008): SJR 0.159 SNIP 0.259
Scopus rating (2007): SJR 0.162 SNIP 0.294
Original language: English
Cochlear implant, Finite element mesh, Automatic generation, Finite element model, Implant optimization
DOIs:
10.1007/s11548-015-1213-2
A virtual seed file: the use of multispectral image analysis in the management of genebank seed accessions

We present a method for multispectral seed phenotyping as a fast and robust tool for managing genebank accessions. A multispectral vision system was used to take images of the seeds of 20 diverse varieties of rice (approximately 30 seeds for each variety). This was followed by extraction of feature information from the images. Multivariate analysis of the feature data was used to classify seed phenotypes according to accession. The proportion of correctly classified rice seeds was 93%. We conclude that the multispectral image analysis could play a role in comparing incoming seeds against existing accessions, identifying different seed types within a sample of seeds and/or in checking whether regenerated seeds match the original seeds.

General information
State: Published
Authors: Adsetts Edberg Hansen, M. (Ekstern), R. Hay, F. (Ekstern), Carstensen, J. M. (Intern)
Number of pages: 4
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Main Research Area: Technical/natural sciences

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Journal: Plant Genetic Resources
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
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Scopus rating (2016): SJR 0.315 SNIP 0.447 CiteScore 0.65
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.276 SNIP 0.337 CiteScore 0.49
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.321 SNIP 0.554 CiteScore 0.75
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.416 SNIP 0.541 CiteScore 1.03
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.397 SNIP 0.494 CiteScore 0.79
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.366 SNIP 0.564 CiteScore 0.75
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.446 SNIP 0.743
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.349 SNIP 0.61
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.391 SNIP 0.705
Scopus rating (2007): SJR 0.467 SNIP 0.712
Scopus rating (2006): SJR 0.23 SNIP 0.369
Scopus rating (2005): SJR 0.161 SNIP 0.407
Scopus rating (2004): SJR 0.123 SNIP 0.355
Scopus rating (2003): SJR 0.174 SNIP 0.26
Scopus rating (2002): SJR 0.181 SNIP 0.379
Scopus rating (2001): SJR 0.243 SNIP 0.221
Scopus rating (2000): SJR 0.264 SNIP 0.63
Bayesian segmentation of brainstem structures in MRI

In this paper we present a method to segment four brainstem structures (midbrain, pons, medulla oblongata and superior cerebellar peduncle) from 3D brain MRI scans. The segmentation method relies on a probabilistic atlas of the brainstem and its neighboring brain structures. To build the atlas, we combined a dataset of 39 scans with already existing manual delineations of the whole brainstem and a dataset of 10 scans in which the brainstem structures were manually labeled with a protocol that was specifically designed for this study. The resulting atlas can be used in a Bayesian framework to segment the brainstem structures in novel scans. Thanks to the generative nature of the scheme, the segmentation method is robust to changes in MRI contrast or acquisition hardware. Using cross validation, we show that the algorithm can segment the structures in previously unseen T1 and FLAIR scans with great accuracy (mean error under 1mm) and robustness (no failures in 383 scans including 168 AD cases). We also indirectly evaluate the algorithm with an experiment in which we study the atrophy of the brainstem in aging. The results show that, when used simultaneously, the volumes of the midbrain, pons and medulla are significantly more predictive of age than the volume of the entire brainstem, estimated as their sum. The results also demonstrate that the method can detect atrophy patterns in the brainstem structures that have been previously described in the literature. Finally, we demonstrate that the proposed algorithm is able to detect differential effects of AD on the brainstem structures. The method will be implemented as part of the popular neuroimaging package FreeSurfer.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Basque Center on Cognition, Brain and Language, Massachusetts General Hospital, Harvard Medical School, Aalto University, University of California, Massachusetts Institute of Technology
Authors: Iglesias, J. E. (Ekstern), Van Leemput, K. (Intern), Bhatt, P. (Ekstern), Casillas, C. (Ekstern), Dutt, S. (Ekstern), Schuff, N. (Ekstern), Truran-Sacrey, D. (Ekstern), Boxer, A. (Ekstern), Fischl, B. (Ekstern)
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Web of Science (2017): Indexed Yes
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Binary pattern flavored feature extractors for Facial Expression Recognition: An overview
This paper conducts a survey of modern binary pattern flavored feature extractors applied to the Facial Expression Recognition (FER) problem. In total, 26 different feature extractors are included, of which six are selected for in depth description. In addition, the paper unifies important FER terminology, describes open challenges, and provides recommendations to scientific evaluation of FER systems. Lastly, it studies the facial expression recognition accuracy and blur invariance of the Local Frequency Descriptor. The paper seeks to bring together disjointed studies, and the main contribution is to provide a solid overview for future research.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Aalborg University, Beijing University of Posts and Telecommunications
Authors: Kristensen, R. L. (Intern), Tan, Z. (Ekstern), Ma, Z. (Ekstern), Guo, J. (Ekstern)
Pages: 1131-1137
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Title of host publication: Proceedings of 38th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)
Boundary Fractal Analysis of Two Cube-oriented Grains in Partly Recrystallized Copper

The protrusions and retrusions observed on the recrystallizing boundaries affect the migration kinetics during recrystallization. Characterization of the boundary roughness is necessary in order to evaluate their effects. This roughness has a structure that can be characterized by fractal analysis, and in this study the so-called “Minkowski sausage” method is adopted. Hereby, two cube-oriented grains in partly recrystallized microstructures are analyzed and quantitative information regarding the dimensions of protrusions/retrusions is obtained.

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Organisations: Department of Wind Energy, Materials science and characterization, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Number of pages: 4
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BFI conference series: International Conference of Textures of Materials (5010972)
Main Research Area: Technical/natural sciences

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Volume: 82
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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.39 SJR 0.187 SNIP 0.499
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.172 SNIP 0.281 CiteScore 0.22
Scopus rating (2014): SJR 0.186 SNIP 0.306 CiteScore 0.18
Scopus rating (2013): SJR 0.183 SNIP 0.256 CiteScore 0.16
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.161 SNIP 0.203 CiteScore 0.14
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.155 SNIP 0.149 CiteScore 0.1
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.151 SNIP 0.112
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Brain Image Motion Correction: Impact of Incorrect Calibration and Noisy Tracking

The application of motion tracking is wide, including: industrial production lines, motion interaction in gaming, computer-aided surgery and motion correction in medical brain imaging. Several devices for motion tracking exist using a variety of different methodologies. In order to use such devices a geometric calibration with the coordinate system in which the motion has to be used is often required. While most devices report a measuring accuracy and precision, reporting a calibration accuracy is not always straight forward. We set out to do a quantitative measure of the impact of both calibration offset and tracking noise in medical brain imaging. The data are generated from a phantom mounted on a rotary stage and have been collected using a Siemens High Resolution Research Tomograph for positron emission tomography. During acquisition the phantom was tracked with our latest tracking prototype. The combined data set form a good basis for a quantitative analysis of calibration accuracy and tracking precision on motion corrected medical images and scanner resolution.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Jensen, R. R. (Intern), Benjaminsen, C. (Intern), Larsen, R. (Intern), Olesen, O. V. (Intern)
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Building damage assessment after the earthquake in Haiti using two postevent satellite stereo imagery and DSMs
In this article, a novel after-disaster building damage monitoring method is presented. This method combines the multispectral imagery and digital surface models (DSMs) from stereo matching of two dates to obtain three kinds of changes: collapsed buildings, newly built buildings and temporary shelters. The proposed method contains three basic steps. The first step is to focus on the DSMs and orthorectified images preparation. The second step is to segment the panchromatic images in obtaining small homogeneous regions. In the last step, a rule-based classification is built on the change information from iteratively reweighted multivariate alteration detection (IR-MAD) and height to extract the three kinds of changes. To further improve the accuracy of the results, a region-based grey-level co-occurrence matrix texture measurement is used. The proposed method is applied to monitor building changes after the 2010 Haiti earthquake, and the obtained results are further evaluated both visually and numerically.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, German Aerospace Center
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Main Research Area: Technical/natural sciences

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Journal: International Journal of Image and Data Fusion
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Canonical analysis based on mutual information

Canonical correlation analysis (CCA) is an established multi-variate statistical method for finding similarities between linear combinations of (normally two) sets of multivariate observations. In this contribution we replace (linear) correlation as the measure of association between the linear combinations with the information theoretical measure mutual information (MI). We term this type of analysis canonical information analysis (CIA). MI allows for the actual joint distribution of the variables involved and not just second order statistics. While CCA is ideal for Gaussian data, CIA facilitates analysis of variables with different genesis and therefore different statistical distributions and different modalities. As a proof of concept we give a toy example. We also give an example with one (weather radar based) variable in the one set and eight spectral bands of optical satellite data in the other set.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Nielsen, A. A. (Intern), Vestergaard, J. S. (Intern)
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Canonical Information Analysis
Canonical correlation analysis is an established multivariate statistical method in which correlation between linear combinations of multivariate sets of variables is maximized. In canonical information analysis introduced here, linear correlation as a measure of association between variables is replaced by the information theoretical, entropy based measure mutual information, which is a much more general measure of association. We make canonical information analysis feasible for large sample problems, including for example multispectral images, due to the use of a fast kernel density estimator for entropy estimation. Canonical information analysis is applied successfully to (1) simple simulated data to illustrate the basic idea and evaluate performance, (2) fusion of weather radar and optical geostationary satellite data in a situation with heavy precipitation, and (3) change detection in optical airborne data. The simulation study shows that canonical information analysis is as accurate as and much faster than algorithms presented in previous work, especially for large sample sizes. URL: http://www.imm.dtu.dk/pubdb/p.php?id=2710

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Authors: Vestergaard, J. S. (Intern), Nielsen, A. A. (Intern)
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Change detection in a time series of polarimetric SAR images

A test statistic for the equality of two or several variance-covariance matrices following the real (as opposed to the complex) Wishart distribution with an associated probability of finding a smaller value of the test statistic is described in the literature [1]. In 2003 we introduced a test statistic for the equality of two variance-covariance matrices following the complex Wishart distribution with an associated probability measure [2]. In that paper we also demonstrated the use of the test statistic to change detection over time in both fully polarimetric and azimuthal symmetric SAR data. To detect change in a series of $k > 2$ complex variance-covariance matrices the pairwise test described in [2] may be applied to either consecutive pairs or to all possible pairs. The former would lead to a lack of ability to detect weak trends over time, the latter to an increase in the probability of false positives (postulating a change when there actually is none) and/or false negatives (missing an actual change). Therefore we need to test for equality for all time points simultaneously. In this paper we demonstrate a new test statistic for the equality of several variance-covariance matrices from the real to the complex Wishart distribution and demonstrate its application to change detection in truly multi-temporal, polarimetric SAR data. Results will be shown that demonstrate the difference between applying to time series of polarimetric SAR images, pairwise comparisons or the new omnibus test statistic, where changes are clearly detected with the omnibus test, on the contrary to the pairwise comparisons, where no changes are detected. We also demonstrate how a factorization of the likelihood ratio statistic into a product of test statistics that each test simpler hypotheses of homogeneity up to a certain point can be used to detect at which points changes occur in the time series. [1] T. W. Anderson, An Introduction to Multivariate Statistical Analysis, John Wiley, New York, third edition, 2003. [2] K. Conradsen, A. A. Nielsen, J. Schou, and H. Skriver, “A test statistic in the complex Wishart distribution and its application to change detection in polarimetric SAR data,” IEEE Transactions on Geoscience and Remote Sensing, vol. 41, no. 1, pp. 4–19.

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Organisations: National Space Institute, Microwaves and Remote Sensing, Department of Applied Mathematics and Computer Science , Image Analysis & Computer Graphics
Authors: Skriver, H. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
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Change detection in bi-temporal data by canonical information analysis

Canonical correlation analysis (CCA) is an established multivariate statistical method for finding similarities between linear combinations of (normally two) sets of multivariate observations. In this contribution we replace (linear) correlation as the measure of association between the linear combinations with the information theoretical measure mutual information (MI). We term this type of analysis canonical information analysis (CIA). MI allows for the actual joint distribution of the variables involved and not just second order statistics. Where CCA is ideal for Gaussian data, CIA facilitates analysis of variables with different genesis and therefore different statistical distributions. As a proof of concept we give a toy example. We also give an example with DLR 3K camera data from two time points covering a motor way.

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Authors: Nielsen, A. A. (Intern), Vestergaard, J. S. (Intern)
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Change Detection in Full and Dual Polarization, Single- and Multifrequency SAR Data

When the covariance matrix formulation is used for multilook polarimetric synthetic aperture radar (SAR) data, the complex Wishart distribution applies. Based on this distribution, a test statistic for equality of two complex variance–covariance matrices and an associated asymptotic probability of obtaining a smaller value of the test statistic are given. In a case study, airborne EMISAR C- and L-band SAR images from the spring of 1998 covering agricultural fields and wooded areas near Foulum, Denmark, are used in single- and bifrequency, bitemporal change detection with full and dual polarimetry data.

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Change detection in polarimetric SAR images using complex Wishart distributed matrices

In surveillance it is important to be able to detect natural or man-made changes e.g. based on sequences of satellite or airborne images of the same area taken at different times. The mapping capability of synthetic aperture radar (SAR) is independent of e.g. cloud cover, and thus this technology holds a strong potential for change detection studies in remote sensing. In polarimetric synthetic aperture radar we measure the amplitude and phase of backscattered signals in four combinations of the linear horizontal and vertical receive and transmit polarizations. These signals form a complex scattering matrix, and after suitable preprocessing the outcome at each picture element (pixel) may be represented as a 3 by 3 Hermitian matrix following a complex Wishart distribution.

One approach to solving the change detection problem based on SAR images is therefore to apply suitable statistical tests in the complex Wishart distribution. We propose a set-up for a systematic solution to the (practical) problems using the likelihood ratio test statistics. We show some examples based on a time series of images with 1024 by 1024 pixels.

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Change detection in quad and dual pol, single- and bi-frequency SAR data

When the covariance matrix representation is used for multi-look polarimetric synthetic aperture radar (SAR) data, the complex Wishart distribution applies. Based on this distribution a likelihood ratio test statistic for equality of two complex variance-covariance matrices and an associated p-value are given. In a case study airborne EMISAR C- and L-band SAR images covering agricultural fields and wooded areas near Foulum, Denmark, are used in single- and bi-frequency, bi-temporal change detection with full and dual polarimetry data. © (2015) COPYRIGHT Society of Photo-Optical Instrumentation Engineers (SPIE).

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Characterization of boundary roughness of two cube grains in partly recrystallized copper

Protrusions and retrusions typically form on recrystallizing boundaries and thus the boundaries often appear rough. Characterization of the boundary roughness is necessary in order to evaluate the effects of protrusions and retrusions on boundary migration. In the current work, a variable termed area integral invariant is employed to provide quantitative information of individual protrusions/retrusions on boundaries surrounding two selected recrystallizing grains in partly recrystallized copper as well as of the overall roughness of the boundaries.

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Cochlear Implant Planning, Selection and Simulation with Patient Specific Data

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen Center for Health Technology, Alma IT Systems, MED-EL GMBH, UPF/ICREA
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BFI (2012): BFI-level 1
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Scopus rating (2011): SJR 0.346 SNIP 0.984 CiteScore 1.4
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Combined Shape and Topology Optimization
Shape and topology optimization seeks to compute the optimal shape and topology of a structure such that one or more properties, for example stiffness, balance or volume, are improved. The goal of the thesis is to develop a method for shape and topology optimization which uses the Deformable Simplicial Complex (DSC) method. Consequently, we present a novel method which combines current shape and topology optimization methods. This method represents the surface of the structure explicitly and discretizes the structure into non-overlapping elements, i.e. a simplicial complex. An
explicit surface representation usually limits the optimization to minor shape changes. However, the DSC method uses a single explicit representation and still allows for large shape and topology changes. It does so by constantly applying a set of mesh operations during deformations of the structure. Using an explicit instead of an implicit representation gives rise to several advantages including straightforward modeling of the surface, improved scalability and ability to optimize multiple materials.

This dissertation describes the essential parts of the novel method for combined shape and topology optimization. This includes the structural analysis in Chapter 2, the optimization in Chapter 3 and the Deformable Simplicial Complex method in Chapter 4. Finally, four applications of the developed method are presented in the included papers and summarized in Chapter 5.

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Combined shape and topology optimization of 3D structures
We present a method for automatic generation of 3D models based on shape and topology optimization. The optimization procedure, or model generation process, is initialized by a set of boundary conditions, an objective function, constraints and an initial structure. Using this input, the method will automatically deform and change the topology of the initial structure such that the objective function is optimized subject to the specified constraints and boundary conditions. For example, this tool can be used to improve the stiffness of a structure before printing, reduce the amount of material needed to construct a bridge, or to design functional chairs, tables, etc. which at the same time are visually pleasing.

The structure is represented explicitly by a simplicial complex and deformed by moving surface vertices and relabeling tetrahedra. To ensure a well-formed tetrahedral mesh during these deformations, the Deformable Simplicial Complex method is used. The deformations are based on optimizing the objective, which in this paper will be maximizing stiffness. Furthermore, the optimization procedure will be subject to constraints such as a limit on the amount of material and the difference from the original shape.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Solid Mechanics
Authors: Christiansen, A. N. (Intern), Bærentzen, J. A. (Intern), Nobel-Jørgensen, M. (Intern), Aage, N. (Intern), Sigmund, O. (Intern)
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Comparison of a multispectral vision system and a colorimeter for the assessment of meat color

The color assessment ability of a multispectral vision system is investigated by a comparison study with color measurements from a traditional colorimeter. The experiment involves fresh and processed meat samples. Meat is a complex material; heterogeneous with varying scattering and reflectance properties, so several factors can influence the instrumental assessment of meat color. In order to assess whether two methods are equivalent, the variation due to these factors must be taken into account. A statistical analysis was conducted and showed that on a calibration sheet the two instruments are equally capable of measuring color. Moreover the vision system provides a more color rich assessment of fresh meat samples with a glossier surface, than the colorimeter. Careful studies of the different sources of variation enable an assessment of the order of magnitude of the variability between methods accounting for other sources of variation leading to the conclusion that color assessment using a multispectral vision system is superior to traditional colorimeter assessments. (C) 2014 Elsevier Ltd. All rights reserved.
Computer-aided diagnosis of pulmonary diseases using x-ray darkfield radiography

In this work we develop a computer-aided diagnosis (CAD) scheme for classification of pulmonary disease for grating-based x-ray radiography. In addition to conventional transmission radiography, the grating-based technique provides a dark-field imaging modality, which utilizes the scattering properties of the x-rays. This modality has shown great potential for diagnosing early stage emphysema and fibrosis in mouse lungs in vivo. The CAD scheme is developed to assist radiologists and other medical experts to develop new diagnostic methods when evaluating grating-based images. The scheme consists of three stages: (i) automatic lung segmentation; (ii) feature extraction from lung shape and dark-field image intensities; (iii) classification between healthy, emphysema and fibrosis lungs. A study of 102 mice was conducted with 34 healthy, 52 emphysema and 16 fibrosis subjects. Each image was manually annotated to build an experimental dataset. System performance was assessed by: (i) determining the quality of the segmentations; (ii) validating emphysema and fibrosis recognition by a linear support vector machine using leave-one-out cross-validation. In terms of segmentation quality, we obtained an overlap percentage (Ω) 92.63 ± 3.65%, Dice Similarity Coefficient (DSC) 89.74 ± 8.84% and Jaccard Similarity Coefficient 82.39 ± 12.62%. For classification, the accuracy, sensitivity and specificity of diseased lung recognition was 100%. Classification between emphysema and fibrosis resulted in an accuracy of 93%, whilst the sensitivity was 94% and specificity 88%. In addition to the automatic classification of lungs, deviation maps created by the CAD scheme provide a visual aid for medical experts to further assess the severity of pulmonary disease in the lung, and highlights regions affected.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, Technische Universität München, Helmholtz Zentrum München, Ludwig-Maximilians-University Hospital Munich
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.08 SJR 1.315 SNIP 1.47
BFI (2015): BFI-level 1
Cone beam computed tomography guided treatment delivery and planning verification for magnetic resonance imaging only radiotherapy of the brain

Background. Radiotherapy based on MRI only (MRI-only RT) shows a promising potential for the brain. Much research focuses on creating a pseudo computed tomography (pCT) from MRI for treatment planning while little attention is often paid to the treatment delivery. Here, we investigate if cone beam CT (CBCT) can be used for MRI-only image-guided radiotherapy (IGRT) and for verifying the correctness of the corresponding pCT.

Material and methods. Six patients receiving palliative cranial RT were included in the study. Each patient had three-dimensional (3D) T1W MRI, a CBCT and a CT for reference. Further, a pCT was generated using a patch-based approach. MRI, pCT and CT were placed in the same frame of reference, matched to CBCT and the differences noted. Paired pCT-CT and pCT-CBCT data were created in bins of 10 HU and the absolute difference calculated. The data were converted to relative electron densities (RED) using the CT or a CBCT calibration curve. The latter was either based on a CBCT phantom (phan) or a paired CT-CBCT population (pop) of the five other patients.

Results. Non-significant (NS) differences in the pooled CT-CBCT, MRI-CBCT and pCT-CBCT transformations were noted. The largest deviations from the CT-CBCT reference were <1 mm and 1°. The average median absolute error (MeAE) in
HU was 184 ± 34 and 299 ± 34 on average for pCT-CT and pCT-CBCT, respectively, and was significantly different (p < 0.01) in each patient. The average MeAE in RED was 0.108 ± 0.025, 0.104 ± 0.011 and 0.099 ± 0.017 for pCT-CT, pCT-CBCT phan (p <0.01 on 2 patients) and pCT-CBCT pop (NS), respectively.

Conclusions. CBCT can be used for patient setup with either MRI or pCT as reference. The correctness of pCT can be verified from CBCT using a population-based calibration curve in the treatment geometry.
Convolutional Neural Networks for SAR Image Segmentation

Segmentation of Synthetic Aperture Radar (SAR) images has several uses, but it is a difficult task due to a number of properties related to SAR images.

In this article we show how Convolutional Neural Networks (CNNs) can easily be trained for SAR image segmentation with good results. Besides this contribution we also suggest a new way to do pixel wise annotation of SAR images that replaces a human expert manual segmentation process, which is both slow and troublesome. Our method for annotation relies on 3D CAD models of objects and scene, and converts these to labels for all pixels in a SAR image.

Our algorithms are evaluated on the Moving and Stationary Target Acquisition and Recognition (MSTAR) dataset which was released by the Defence Advanced Research Projects Agency during the 1990s. The method is not restricted to the type of targets imaged in MSTAR but can easily be extended to any SAR data where prior information about scene geometries can be estimated.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Solid Mechanics
Authors: Malmgren-Hansen, D. (Intern), Nobel-Jørgensen, M. (Intern)
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Correction of Motion Artifacts for Real-Time Structured Light

While the problem of motion is often mentioned in conjunction with structured light imaging, few solutions have thus far been proposed. A method is demonstrated to correct for object or camera motion during structured light 3D scene acquisition. The method is based on the combination of a suitable pattern strategy with fast phase correlation image registration. The effectiveness of this approach is demonstrated on motion corrupted data of a real-time structured light system, and it is shown that it improves the quality of surface reconstructions visually and quantitively.

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Authors: Wilm, J. (Intern), Olesen, O. V. (Intern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
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Dictionary Based Segmentation in Volumes

We present a method for supervised volumetric segmentation based on a dictionary of small cubes composed of pairs of intensity and label cubes. Intensity cubes are small image volumes where each voxel contains an image intensity. Label cubes are volumes with voxelwise probabilities for a given label. The segmentation process is done by matching a cube from the volume, of the same size as the dictionary intensity cubes, to the most similar intensity dictionary cube, and from the associated label cube we get voxel-wise label probabilities. Probabilities from overlapping cubes are averaged and hereby we obtain a robust label probability encoding. The dictionary is computed from labeled volumetric image data based on weighted clustering. We experimentally demonstrate our method using two data sets from material science – a phantom data set of a solid oxide fuel cell simulation for detecting three phases and their interfaces, and a tomogram of a glass fiber composite used in wind turbine blades for detecting individual glass fibers.

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Dictionary Based Segmentation in Volumes

Method for supervised segmentation of volumetric data. The method is trained from manual annotations, and these annotations make the method very flexible, which we demonstrate in our experiments. Our method infers label information locally by matching the pattern in a neighborhood around a voxel to a dictionary, and hereby accounts for the volume texture.

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Differential effects of strength training and testosterone treatment on soluble CD36 in aging men: Possible relation to changes in body composition

Purpose. We measured soluble CD36 (sCD36) and body composition to determine the effects of testosterone treatment (TT) and/or strength training (ST) on cardiovascular risk in men with low normal testosterone levels. Methods. Double-blinded, placebo-controlled study in 54 men aged 60-78 years with bioavailable testosterone <7.3 nmol/L and waist > 94 cm randomized to TT (gel, 50-100 mg/day, n = 20), placebo (n = 18) or ST (n = 16) for 6 months. Moreover, the ST group was randomized to TT (ST + TT, n = 7) or placebo (ST + placebo, n = 9) after 3 months. Outcomes. sCD36, total and regional fat mass were established by Dual X-ray absorptiometry and magnetic resonance imaging. Data are presented as median (quartiles). Kruskal-Wallis and Mann-Whitney tests were performed on delta values at 0, 3 and 6 months. Results. ST + placebo decreased sCD36 levels by 21% [from 0.80 (0.68-1.22) to 0.63 (0.51-0.73) rel. units] vs. TT and vs. placebo (p <0.05). ST + placebo did not change bioavailable testosterone and lean body mass. Fat mass measures significantly improved during ST + placebo, ST + TT, and TT vs. placebo. During ST + placebo, delta sCD36 was associated with delta total fat mass (r = 0.81) and delta central fat mass (r = 0.84). Conclusions. Compared to testosterone treatment, six months of strength training reduced sCD36 levels suggesting decreased cardiovascular risk, possibly due to a reduction in central fat mass.

General information
State: Published
Organisations: Image Analysis & Computer Graphics, Department of Applied Mathematics and Computer Science, Odense University Hospital, University of Southern Denmark, Statens Serum Institut, Aalborg University
Authors: Glintborg, D. (Ekstern), Christensen, L. L. (Ekstern), Kvorning, T. (Ekstern), Larsen, R. (Intern), Højlund, K. (Ekstern), Brixen, K. (Ekstern), Hougaard, D. M. (Ekstern), Handberg, A. (Ekstern), Andersen, M. (Ekstern)
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.584 SNIP 0.69 CiteScore 1.4
BFI (2015): BFI-level 1
Discriminating Yogurt Microstructure Using Diffuse Reflectance Images

The protein microstructure of many dairy products is of great importance for the consumers' experience when eating the product. However, studies concerning discrimination between protein microstructures are limited. This paper presents preliminary results for discriminating different yogurt microstructures using hyperspectral (500-900nm) diffuse reflectance images (DRIs) – a technique potentially well suited for inline process control. Comparisons are made to quantified measures of the yogurt microstructure observed through confocal scanning laser microscopy (CSLM). The output signal from both modalities is evaluated on a 24 factorial design covering four common production parameters, which significantly change the chemistry and the microstructure of the yogurt. It is found that the DRIs can be as discriminative as the CSLM images in certain cases, however the performance is highly governed by the chemistry of the sample. Also, the DRIs shows better correlation to the CSLM images and are more discriminative when considering shorter wavelengths.

General information
State: Published
Evaluation of Yogurt Microstructure Using Confocal Laser Scanning Microscopy and Image Analysis

The microstructure of protein networks in yogurts defines important physical properties of the yogurt and hereby partly its quality. Imaging this protein network using confocal scanning laser microscopy (CSLM) has shown good results, and CSLM has become a standard measuring technique for fermented dairy products. When studying such networks, hundreds of images can be obtained, and here image analysis methods are essential for using the images in statistical analysis. Previously, methods including gray level co-occurrence matrix analysis and fractal analysis have been used with success. However, a range of other image texture characterization methods exists. These methods describe an image by a frequency distribution of predefined image features (denoted textons). Our contribution is an investigation of the choice of image analysis methods by performing a comparative study of 7 major approaches to image texture description. Here, CSLM images from a yogurt fermentation study are investigated, where production factors including fat content, protein content, heat treatment, and incubation temperature are varied. The descriptors are evaluated through nearest neighbor classification, variance analysis, and cluster analysis. Our investigation suggests that the texton-based descriptors provide a fuller description of the images compared to gray-level co-occurrence matrix descriptors and fractal analysis, while still being as applicable and in some cases as easy to tune.

Practical Application
Confocal laser scanning microscopy images can be used to provide information on the protein microstructure in yogurt products. For large numbers of microscopy images, subjective evaluation becomes a difficult or even impossible approach, if the images should be incorporated in any form of statistical analysis alongside other measuring modalities or sensory data. Instead, automated image texture analysis can be used to provide objective descriptions of the images, and we provide a comparative study for a broad range of the many image texture analysis available. All of the investigated techniques should be applicable for any type of pseudo homogeneous image structures.
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.77 SNIP 1.013 CiteScore 1.92
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.83 SNIP 0.985 CiteScore 1.97
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.937 SNIP 1.11 CiteScore 2.07
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.011 SNIP 1.079 CiteScore 2.24
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.978 SNIP 1.086 CiteScore 1.98
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.934 SNIP 1.058 CiteScore 1.9
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.047 SNIP 1.101
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.969 SNIP 1.001
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.886 SNIP 0.924
Scopus rating (2007): SJR 0.695 SNIP 0.966
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.724 SNIP 0.895
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.676 SNIP 1.02
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.743 SNIP 1.025
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.705 SNIP 1.018
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.388
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.843 SNIP 1.144
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.898 SNIP 1.34
Scopus rating (1999): SJR 1.061 SNIP 1.3
Original language: English
FOOD, ACID MILK GELS, LEVEL COOCCURRENCE MATRICES, LOCAL BINARY PATTERNS, PLASMA-PROTEIN GELS, PHYSICAL-PROPERTIES, WHEY-PROTEIN, SKIM MILK, TEXTURE CLASSIFICATION, RHEOLOGICAL PROPERTIES, FRACTAL ANALYSIS, image processing, microstructure, quantification, statistics, yogurt
Electronic versions:
DOIs: 10.1111/1750-3841.12885
Source: FindIt
Source-ID: 275367739
Publication: Research - peer-review › Journal article – Annual report year: 2015
Fresh meat color evaluation using a structured light imaging system
The objective of this study was to investigate the efficacy of a computer vision system (CVS) with structured light for meat color assessment. Three muscles (longissimus dorsi (LD), semimembranosus (SM), and psoas major (PM)) from eight beef carcasses were obtained at 1 day postmortem, vacuum packaged and assigned to three aging periods (9, 16, and 23 days). After aging, steaks were cut and displayed for 7 days at 3 °C under light. The surface colors were evaluated by using a Minolta, the CVS and trained color panel. In general, the CVS was highly correlated to the sensory scores, and showed an equivalent meat color assessment compared to the colorimeter. The CVS had a significantly higher correlation with the panel scores for the lighter and more color stable samples compared to the colorimeter. These results indicate that the CVS with structured light could be an appropriate alternative to the traditional colorimeter by offering improved precision and accuracy over the colorimeter.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Purdue University
Authors: Trinderup, C. H. (Intern), Kim, Y. H. B. (Ekstern)
Pages: 100-107
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
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Scopus rating (2016): CiteScore 3.87 SJR 1.589 SNIP 1.682
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.518 SNIP 1.641 CiteScore 3.66
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.496 SNIP 1.761 CiteScore 3.52
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.522 SNIP 1.818 CiteScore 3.68
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.597 SNIP 1.774 CiteScore 3.31
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.515 SNIP 1.701 CiteScore 3.42
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.356 SNIP 1.434
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.46 SNIP 1.525
BFI (2008): BFI-level 2
The 19th Scandinavian Conference on Image Analysis was held at the IT University of Copenhagen in Denmark during June 15-17, 2015. The SCIA conference series has been an ongoing biannual event for more than 30 years and over the years it has nurtured a world-class regional research and development area within the four participating Nordic countries. It is a regional meeting of the International Association for Pattern Recognition (IAPR).

We would like to thank all authors who submitted works to this year’s SCIA, the invited speakers, and our Program Committee.

In total 67 papers were submitted to SCIA 2015 and were reviewed by members of the Program Committee and additional reviewers. Each paper was reviewed by at least two independent reviewers followed by a meta-review by the Program Committee. Finally, 26 papers were chosen for oral presentation and 19 papers for poster presentation. The topics of the accepted papers range from novel applications of vision systems, pattern recognition, machine learning, feature extraction, segmentation, 3D vision, to medical and biomedical image analysis. The papers originate from all the Scandinavian countries and several other European countries.

It is our sincere hope that the participants had an enjoyable and fruitful experience, both scientifically and socially, in Copenhagen.
Better understanding of the anatomical variability of the human cochlear is important for the design and function of Cochlear Implants. Good non-rigid alignment of high-resolution cochlear μCT data is a challenging task.

In this paper we study the use of heat distribution similarity between samples as an anatomical registration prior. We set-up and present our heat distribution model for the cochlea and utilize it in a typical cubic B-spline registration model. Evaluation and comparison is done against a corresponding normal registration of binary segmentations.
Individualized directional microphone optimization in hearing aids based on reconstructing the 3D geometry of the head and ear from 2D images

The goal of this thesis is to improve intelligibility for hearing-aid users by individualizing the directional microphone in a hearing aid. The general idea is a three step pipeline for easy acquisition of individually optimized directional filters. The first step is to estimate an individual 3D head model based on 2D images, the second step is to simulate individual head related transfer functions (HRTFs) based on the estimated 3D head model and the final step is to calculate optimal directional filters based on the simulated HRTFs. The pipeline is employed on a Behind-The-Ear (BTE) hearing aid.

We verify the directional filters optimized from simulated HRTFs based on a listener-specific head model against two set of optimal filters. The first set of optimal filters is calculated from HRTFs measured on a 3D printed version of the head model. The second set of optimal filters is calculated from HRTFs measured on the actual human subject.

A verification of the 'simulated' directional filters against the optimal filters for the human subject revealed a 0.5 dB reduction in articulation-index weighted directivity index, which corresponds to 5% less speech intelligibility. A comparison against non-individual directional filters revealed equally high Articulation-Index weighted Directivity Index (AI-DI) values for our specific test subject. However, measurements on other individuals indicate that the performance of the non-individual filters vary among subjects, and in particular individuals who deviate from an average of the population could benefit from having individualized filters.

We developed a pipeline for 3D printing of full size human heads. The 3D printed head facilitated the second verification step, which revealed a 0.3 dB reduction from optimal to simulated directional filters. This indicates that the simulation are more similar to measurements on the 3D printed head than measurements on the human subject. We suggest that the larger difference between simulation and human measurements could arise due to small geometrical errors in the head model or due to differences in acoustical properties between human skin and virtual material properties in the simulation.

The BTE hearing aid showed very little room for improvement using individualized directional filters, however the directional filters in an In-The-Ear (ITE) hearing aid revealed an improvement in AI-DI values of up to 3.6 dB between an average filter and an optimal filter. This suggests that hearing-aid users with ITE hearing aids could benefit more from having individualized directional filters than what was shown for a BTE hearing aid.

This thesis is a step towards individualizing the directional microphone in hearing aids, which could contribute with improved sound for a group of hearing-aid users. In particular, we believe that ITE hearing-aid users could have a large benefit from an individualized directional microphone.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Harder, S. (Intern), Paulsen, R. R. (Intern)
Number of pages: 193
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Injectable Colloidal Gold for Use in Intrafractional 2D Image-Guided Radiation Therapy

In the western world, approximately 50% of all cancer patients receive radiotherapy alone or in combination with surgery or chemotherapy. Image-guided radiotherapy (IGRT) has in recent years been introduced to enhance precision of the delivery of radiation dose to tumor tissue. Fiducial markers are often inserted inside the tumor to improve IGRT precision and to enable monitoring of the tumor position during radiation therapy. In the present article, a liquid fiducial tissue marker is presented, which can be injected into tumor tissue using thin and flexible needles. The liquid fiducial has high radio-opacity, which allows for marker-based image guidance in 2D and 3D X-ray imaging during radiation therapy. This is achieved by surface-engineering gold nanoparticles to be highly compatible with a carbohydrate-based gelation matrix. The new fiducial marker is investigated in mice where they are highly biocompatible and stable after implantation. To investigate the clinical potential, a study is conducted in a canine cancer patient with spontaneous developed solid tumor in which the marker is successfully injected and used to align and image-guide radiation treatment of the canine patient. It is concluded that the new fiducial marker has highly interesting properties that warrant investigations in cancer patients.
Interactive Global Illumination Effects Using Deterministically Directed Layered Depth Maps

A layered depth map is an extension of the well-known depth map used in rasterization. Multiple layered depth maps can be used as a coarse scene representation. We develop two global illumination methods which use said scene representation. The first is an interactive ambient occlusion method. The second is an interactive single-bounce indirect lighting method based on photon differentials. All of this is implemented in a rasterization-based pipeline.
Interpretation of images from intensity, texture and geometry

The goal of the thesis is to develop flexible mathematical methods for quantitative interpretation of image content. Problems from research areas as diverse as evolutionary biology, remote sensing and materials science have motivated the methodological development. The solutions are inspired by classical mathematical image analysis techniques, information theory, probabilistic graphical models and manifold learning.

Specifically, the thesis revolves around describing three major components of images, namely intensity, texture and geometry. Intensity distribution modelling is important for obtaining useful global representations of the raw image data. Texture description provides a local representation of the image content, useful for descriptive and discriminative scenarios. Geometrical knowledge of the image content is leveraged within the framework of Markov random fields. Mathematical models are developed around these three topics and constitute building blocks useful for engineering image-based solutions to a wide range of problems.

The contributions include automated quantification of frog patterning from field imagery, statistical methods for estimating the genetic basis of quantified mimicry phenotypes, estimation of the atomic structure of graphene from low-contrast transmission electron microscopy images and patch-based crop classification from synthetic aperture radar data. Further, an information theoretic approach to two-set image decomposition is presented, representing a purely methodological contribution.

This thesis makes statistical image analysis available to fellow researchers with domain specific problems, and provides new methodology relevant for the field itself.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Vestergaard, J. S. (Intern), Larsen, R. (Intern), Nielsen, A. A. (Intern)
Number of pages: 290
Publication date: 2015
Kernel versions of some orthogonal transformations

Kernel versions of orthogonal transformations such as principal components are based on a dual formulation also termed Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products of the original data are replaced by inner products between nonlinear mappings into higher dimensional feature space. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel principal component analysis (PCA) and kernel minimum noise fraction (MNF) analyses handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. Although more generally useful the techniques are here used for change detection in multispectral remote sensing images.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Nielsen, A. A. (Intern)
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Source-ID: 118476509
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Markerless PET motion correction: tracking in narrow gantries through optical fibers

In a time with increasing resolution and signal-to-noise ratio of medical 3D brain scanners, there is also an increased need for tracking and motion correction of patient movements during acquisition time. To successfully implement a system for motion tracking in the clinic, the system should be accurate while only adding minimal complexity to the workflow. We present: Tracoline 2.0, a surface scanner prototype, which allows for markerless tracking in the clinic. The system uses structured light through optical fibre bundles, which easily fit in narrow gantries. The optical fibres also makes the system compatible with magnetic resonance (MR) imaging since all the electronics are moved away from the scanner. We demonstrate the system in a positron emission tomography (PET) study using the Siemens high resolution research tomography (HRRT). With two Ge/Ga-68 line sources fitted in a mannequin head mounted on a rotating stage we evaluate the system for stepwise motion with periods of rest and for continuous motion. Based on comparison with the ground truth of the rotating stage, we were able to accurately track the movement with a rotational error of -0.073° to 0.098° with a maximal SD of 0.031° for rotations up to ±25°. Based on the tracking results the PET frames were also successfully corrected for motion by aligning 10 s frames without motion for the stepwise experiment and aligning 1 s frames for the experiment with continuous motion. We have demonstrated and evaluated a system for markerless tracking and motion correction. The system is a significant step towards markerless tracking and motion correction seamlessly implemented in the clinic.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Authors: Jensen, R. R. (Intern), Olesen, O. V. (Intern), Benjaminsen, C. (Intern), Højgaard, L. (Ekstern), Larsen, R. (Intern)
Number of pages: 3
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M10 MIC Poster Session I - Data Analysis & Image Generation I. Presentation: M10-24
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Source-ID: 105776167
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015
Maturational trajectories of subcortical grey matter microstructure: A longitudinal study

General information
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Organizations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of California, San Diego, Copenhagen University Hospital
Authors: Madsen, K. S. (Ekstern), Jernigan, T. L. (Ekstern), Johansen, L. B. (Ekstern), Lyksborg, M. (Intern), Thompson, W. K. (Ekstern), Baaré, W. F. (Ekstern)
Number of pages: 1
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:
3652_Madsen.pdf
Source: PublicationPreSubmission
Source-ID: 118355975
Publication: Research - peer-review › Poster – Annual report year: 2015

Multispectral Imaging of Meat Quality - Color and Texture
The use of computer vision systems in food production and development is increasing. Computer vision systems offer fast, reliable, objective and noninvasive methods for assessment of wanted quality traits.

This thesis investigates the applicability of computer vision systems in the assessment of meat quality parameters, especially with regards to meat color and texture. Several image modalities have been applied, all considering multi- or hyper spectral imaging.

The work demonstrates the use of computer vision systems for meat color measurements. The color is assessed by suitable transformations to the CIELAB color space, the common color space within food science. The results show that meat color assessment with a multispectral imaging is a great alternative to the traditional colorimeter, i.e. the vision system meets some of the limitations that the colorimeter possesses. To mention one, it is possible to assess color of very complicated structures, such as salamis, with a vision system. More importantly though, the vision system embraces the complicated scattering properties of meat.

The images can also lead to other analyses, e.g. image texture analysis relating to the structure of the meat. In the thesis it is presented how simple texture measures can be used for characterizing the texture changes in fermented salamis. Moreover, it was investigated if it was possible to relate structure in images to chemical compounds in lard from boars.

General information
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Organizations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Trinderup, C. H. (Intern), Conradsen, K. (Intern), Dahl, A. B. (Intern)
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Electronic versions:
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Publication: Research › Ph.D. thesis – Annual report year: 2015

Nanoparticles and nanolmaging for organic solar cells
Solar energy is one of the few energy sources with the potential to power humanity in a future scenario where fossil fuels are not attractive due to their effect on the global climate or fossil fuels have been depleted all together. Organic photovoltaics is a promising technology for solar harvesting due to its potential for scalable roll-to-roll production and low manufacturing cost. However, the technology is faced with several obstacles which have to be overcome such as low
efficiency and stability. Some of the issues are related to nano structures and device morphology. This dissertation is devoted to studying organic photovoltaics on the micro to nanometer scale, in particular photoactive Landfester particles. The ultimate goal is to increase the performance of Landfester particle layers so they can become a viable alternative to photoactive layers cast from organic solvent. Transition to a water based ink would provide a production environment without toxic fumes from organic solvents and the nanoparticle structure would provide additional morphological control. The first part of the dissertation maps photodegradation in active layers cast from organic solvents. Reduction in degradation rates is quantified for mixed electron donor and acceptor material. The spatial distribution of photodegradation in an electron donor material is mapped and the degradation is found to be homogeneous at the sub-micron length scale. The second and third part is devoted to studying the nano structures in photoactive Landfester nanoparticles. The dispersed particles are characterized by size, internal structure and crystallinity. Crystal orientation and spatial distribution of materials are quantified for cast layers of Landfester particles. A layer of particles is also investigated in a tandem solar cell and compared to other layers in the structure using Tomographic 3D mapping. The fourth part presents a projection alignment algorithm for tomographic methods. It works by estimating projection movement through iterative logic using projection distance minimization. It is tested on simulated datasets and results in decreased angular displacements and increased spatial resolution. Further development of the algorithm could therefore be used to increase spatial resolution for characterization of organic photovoltaics and computed tomography in general.

General information
State: Published
Organisations: Department of Energy Conversion and Storage, Imaging and Structural Analysis, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Pedersen, E. B. L. (Intern), Andreasen, J. W. (Intern), Aanæs, H. (Intern)
Number of pages: 171
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Public information
Publisher: Department of Energy Conversion and Storage, Technical University of Denmark
Original language: English
Series: ECS-Ph.D
Main Research Area: Technical/natural sciences
Publication: Research › Ph.D. thesis – Annual report year: 2015

New equations to calculate 3D joint centres in the lower extremities
Biomechanical movement analysis in 3D requires estimation of joint centres in the lower extremities and this estimation is based on extrapolation from markers placed on anatomical landmarks. The purpose of the present study was to quantify the accuracy of three established set of equations and provide new improved equations to predict the joint centre locations. The ‘true’ joint centres of the knee and ankle joint were obtained in vivo by MRI scans on 10 male subjects whereas the ‘true’ hip joint centre was obtained in 10 male and 10 female cadavers by CT scans.

For the hip joint the errors ranged from 26.7 (8.9) to 29.6 (7.5) mm, for the knee joint 5.8 (3.1) to 22.6 (3.3) mm and for the ankle joint 14.4 (2.2) to 27.0 (4.6) mm. This differed significantly from the improved equations by which the error for the hip joint ranged from 8.2 (3.6) to 11.6 (5.6) mm, for the knee joint from 2.9 (2.1) to 4.7 (2.5) mm and for the ankle joint from 3.4 (1.3) to 4.1 (2.0) mm. The coefficients in the new hip joint equations differed significantly between sexes. This difference depends on anatomical differences of the male and female pelvis.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen, Copenhagen University Hospital, Aalborg University
Authors: Sandau, M. (Ekstern), Heimbürger, R. V. (Ekstern), Villa, C. (Ekstern), Jensen, K. E. (Ekstern), Moeslund, T. B. (Ekstern), Aanæs, H. (Intern), Alkjær, T. (Ekstern), Simonsen, E. B. (Ekstern)
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Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
The quality of a dairy product is largely determined by its microstructure which also affects its optical properties. Consequently, an assessment of the optical properties during production may be part of a feedback system for ensuring the quality of the production process. This paper presents a novel camera-based measurement technique that enables robust quantification of a wide range of reduced scattering coefficients and absorption coefficients. Measurements are based on hyperspectral images of diffuse reflectance in the wavelength range of 470 to 1020 nm. The optical properties of commercially available milk and yogurt products with three different levels of fat content are measured. These constitute a relevant range of products at a dairy plant. The measured reduced scattering properties of the samples are presented and show a clear discrimination between levels of fat contents as well as fermentation. The presented measurement technique and method of analysis is thus suitable for a rapid, noncontact, and non-invasive inspection that can deduce physically interpretable properties.
On Optimal, Minimal BRDF Sampling for Reflectance Acquisition

The bidirectional reflectance distribution function (BRDF) is critical for rendering, and accurate material representation requires data-driven reflectance models. However, isotropic BRDFs are 3D functions, and measuring the reflectance of a flat sample can require a million incident and outgoing direction pairs, making the use of measured BRDFs impractical. In this paper, we address the problem of reconstructing a measured BRDF from a limited number of samples. We present a novel mapping of the BRDF space, allowing for extraction of descriptive principal components from measured databases, such as the MERL BRDF database. We optimize for the best sampling directions, and explicitly provide the optimal set of incident and outgoing directions in the Rusinkiewicz parameterization for \( n \in \{1, 2, 5, 10, 20\} \) samples. Based on the principal components, we describe a method for accurately reconstructing BRDF data from these limited sets of samples. We validate our results on the MERL BRDF database, including favorable comparisons to previous sets of industry-standard sampling directions, as well as with BRDF measurements of new flat material samples acquired with a gantry system. As an extension, we also demonstrate how this method can be used to find optimal sampling directions when imaging a sphere of a homogeneous material; in this case, only two images are often adequate for high accuracy.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of California, San Diego
Authors: Nielsen, J. B. (Intern), Jensen, H. W. (Ekstern), Ramamoorthi, R. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Web of Science (2016): Indexed yes
Scopus rating (2016): CiteScore 5.69 SJR 2.45 SNIP 2.496
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.171 SNIP 3.744 CiteScore 6.24
Web of Science (2015): Indexed yes
Optimal Iterated Two-Class Separation in Hyperspectral Data

This paper gives an iterated extension of canonical discriminant analysis (CDA) for separation between two groups or classes in multi- or hypervariate data. We show that the iterative extension greatly enhances the separation between classes in a case with 110-band HyMap data covering part of the Sokolov mining area in the Czech Republic. Below three spectral bands of the original data (red 848 nm, green 1.781 nm and blue 681 nm) and the iterated canonical variate that based on an initial training area gives the optimal separation (in the CDA sense) between “water” and “everything else” are shown.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, German Aerospace Center
Authors: Nielsen, A. A. (Intern), Müller, A. (Ekstern)
Number of pages: 1
Publication date: 2015
Main Research Area: Technical/natural sciences
Oriented Shape Index Histograms for Cell Classification
We propose a novel extension to the shape index histogram feature descriptor where the orientation of the second-order curvature is included in the histograms. The orientation of the shape index is reminiscent but not equal to gradient orientation which is widely used for feature description. We evaluate our new feature descriptor using a public dataset consisting of HEP-2 cell images from indirect immunofluorescence lighting. Our results show that we can improve classification performance significantly when including the shape index orientation. Notably, we show that shape index orientation outperforms the gradient orientation on the dataset.

Our 3D Vision Data-Sets in the Making
Purpose: In radiotherapy (RT) based on magnetic resonance imaging (MRI) as the only modality, the information on electron density must be derived from the MRI scan by creating a so-called pseudo computed tomography (pCT). This is a nontrivial task, since the voxel-intensities in an MRI scan are not uniquely related to electron density. To solve the task, voxel-based or atlas-based models have typically been used. The voxel-based models require a specialized dual ultrashort echo time MRI sequence for bone visualization and the atlas-based models require deformable registrations of conventional MRI scans. In this study, we investigate the potential of a patch-based method for creating a pCT based on conventional T1-weighted MRI scans without using deformable registrations. We compare this method against two state-of-the-art methods within the voxel-based and atlas-based categories.
Methods: The data consisted of CT and MRI scans of five cranial RT patients. To compare the performance of the different methods, a nested cross validation was done to find optimal model parameters for all the methods. Voxel-wise and geometric evaluations of the pCTs were done. Furthermore, a radiologic evaluation based on water equivalent path lengths was carried out, comparing the upper hemisphere of the head in the pCT and the real CT. Finally, the dosimetric accuracy was tested and compared for a photon treatment plan.

Results: The pCTs produced with the patch-based method had the best voxel-wise, geometric, and radiologic agreement with the real CT, closely followed by the atlas-based method. In terms of the dosimetric accuracy, the patch-based method had average deviations of less than 0.5% in measures related to target coverage.

Conclusions: We showed that a patch-based method could generate an accurate pCT based on conventional T1-weighted MRI sequences and without deformable registrations. In our evaluations, the method performed better than existing voxel-based and atlas-based methods and showed a promising potential for RT of the brain based only on MRI.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Pages: 1596-1605
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.46 SJR 1.227 SNIP 1.299
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.307 SNIP 1.553 CiteScore 2.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.523 SNIP 1.631 CiteScore 2.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.766 SNIP 1.767 CiteScore 3.17
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.42 SNIP 1.669 CiteScore 3.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.353 SNIP 1.627 CiteScore 3.03
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.617 SNIP 1.744
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.534 SNIP 2.046
Web of Science (2009): Indexed yes
Patient-Specific Virtual Insertion of Electrode Array for Electrical Simulations of Cochlear Implants

General information
State: Published
Authors: Mangado, N. (Ekstern), Duchateau, N. (Ekstern), Ceresa, M. (Ekstern), Kjer, H. M. (Intern), Vera, S. (Ekstern), Mistrik, P. (Ekstern), Herrero, J. (Ekstern), Ballester, M. G. (Ekstern)
Pages: S102-S103
Publication date: 2015
Conference: 29th International Congress on Computer Assisted Radiology and Surgery (CARS 2015), Barcelona, Spain, 24/06/2015 - 24/06/2015
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Scopus rating (2016): CiteScore 1.76 SJR 0.522 SNIP 1.291
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.481 SNIP 1.108 CiteScore 1.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.486 SNIP 1.301 CiteScore 1.79
BFI (2013): BFI-level 1
Predicting Color Output of Additive Manufactured Parts

In this paper we address the colorimetric performance of a multicolor additive manufacturing process. A method on how to measure and characterize color performance of said process is presented. Furthermore, a method on predicting the color output is demonstrated, allowing for previsualization of parts prior to print. Results show that color prediction can be achieved with an average color difference error of $\Delta E^{*00} = 1.5$ and std.dev $\sigma = 0.75$, with similar order of magnitude as the literature defined threshold for „Just Noticeable Difference“ (JND).

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Manufacturing Engineering
Authors: Eiríksson, E. R. (Intern), Pedersen, D. B. (Intern), Aanæs, H. (Intern)
Pages: 95-99
Publication date: 2015

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Volume: 60
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ISBN (Print): 978-1-887706-67-4
Main Research Area: Technical/natural sciences
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PREDICTING_COLOR_OUTPUT_OF_ADDITIVE_MANUFACTURED.pdf
Source: PublicationPreSubmission
Source-ID: 116622061
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Predicting Detailed Inner Ear Anatomy from Pre-Oppreational CT for cochlear implant surgery

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen Center for Health Technology, Alma Medical Systems, Universitat Pompeu Fabra
Authors: Kjer, H. M. (Intern), Vera, S. (Ekstern), Fagertun, J. (Intern), Peréz, F. (Ekstern), Herrero, J. (Ekstern), Ballester, M. G. (Ekstern), Paulsen, R. R. (Intern)
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Publication date: 2015
Conference: 29th International Congress on Computer Assisted Radiology and Surgery (CARS 2015), Barcelona, Spain, 24/06/2015 - 24/06/2015
Main Research Area: Technical/natural sciences

Publication information
Predicting facial characteristics from complex polygenic variations

Research into the importance of the human genome in the context of facial appearance is receiving increasing attention and has led to the detection of several Single Nucleotide Polymorphisms (SNPs) of importance. In this work we attempt a holistic approach predicting facial characteristics from genetic principal components across a population of 1,266 individuals. For this we perform a genome-wide association analysis to select a large number of SNPs linked to specific facial traits, recode these to genetic principal components and then use these principal components as predictors for facial traits in a linear regression. We show in this proof-of-concept study for facial trait prediction from genome-wide SNP data that some facial characteristics can be modeled by genetic information: facial width, eyebrow width, distance between eyes, and features involving mouth shape are predicted with statistical significance (p < 0.03).
Quality Assurance Based on Descriptive and Parsimonious Appearance Models

In this positional paper, we discuss the potential benefits of using appearance models in additive manufacturing, metal casting, wind turbine blade production, and 3D content acquisition. Current state of the art in acquisition and rendering of appearance cannot easily be used for quality assurance in these areas. The common denominator is the need for descriptive and parsimonious appearance models. By ‘parsimonious’ we mean with few parameters so that a model is useful both for fast acquisition, robust fitting, and fast rendering of appearance. The word ‘descriptive’ refers to the fact that a model should represent the main features of the acquired appearance data. The solution we propose is to reduce the degrees of freedom by greater use of multivariate statistics.

General information
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Organisations: Department of Applied Mathematics and Computer Science , Image Analysis & Computer Graphics
Number of pages: 4
Publication date: 2015

Host publication information
Title of host publication: MAM2015: Eurographics Workshop on Material Appearance Modeling: Issues and Acquisition
Quantification of Brain Access of Exendin-4 in the C57BL Mouse Model by SPIM Fluorescence Imaging and the Allen Mouse Brain Reference Model

With the recent advance in 3D microscopy such as Single Plane Illumination Microscopy (SPIM) it is possible to obtain high resolution image volumes of the entire mouse brain. These data can be used to study the access of several peptides such as the glucagon-like peptide-1 (GLP-1) analogue Exendin-4, into the brain with the aim of developing medication for obesity. To investigate mode of action of the medication it is important to identify the specific anatomical brain nuclei that are targeted by the compound. Such segmentations can be obtained using an annotated digital brain atlas. We construct a SPIM brain atlas based on the Allen mouse brain 3D reference model and use it to analyze the access of peripherally injected Exendin-4 into the brain compared to a negative control group. The constructed atlas consists of an average SPIM volume obtained from eight C57BL mouse brains using group-wise registration. A cross-modality registration is performed between the constructed average volume and the Allen mouse brain reference model to allow propagation of annotations to the SPIM average brain. Finally, manual corrections of the annotations are performed and validated by visual inspection. The study shows that Exendin-4 have access to brain regions such as the arcuate hypothalamic nucleus and the nucleus of the solitary tract, which are areas involved in regulating food intake.

Quantifying uncertainty in sustainability assessments: from feedstock to end-of-life

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Bisinella, V. (Intern), Conradsen, K. (Intern), Damgaard, A. (Intern), Christensen, T. H. (Intern), Astrup, T. F. (Intern)
Number of pages: 1
Publication date: 2015

Objective: An increasing number of human in vivo magnetic resonance imaging (MRI) studies have focused on examining the structure and function of the subfields of the hippocampal formation (the dentate gyrus, CA fields 1 – 3, and the subiculum) and subregions of the parahippocampal gyrus (entorhinal, perirhinal, and parahippocampal cortices). The ability to interpret the results of such studies and to relate them to each other would be improved if a common standard existed for labeling hippocampal subfields and parahippocampal subregions. Currently, research groups label different subsets of structures and use different rules, landmarks, and cues to define their anatomical extents. This paper characterizes, both qualitatively and quantitatively, the variability in the existing manual segmentation protocols for labeling hippocampal and parahippocampal substructures in MRI, with the goal of guiding subsequent work on developing a harmonized substructure segmentation protocol.

Method: MRI scans of a single healthy adult human subject were acquired both at 3 T and 7 T. Representatives from 21 research groups applied their respective manual segmentation protocols to the MRI modalities of their choice. The resulting set of 21 segmentations was analyzed in a common anatomical space to quantify similarity and identify areas of agreement.

Results: The differences between the 21 protocols include the region within which segmentation is performed, the set of anatomical labels used, and the extents of specific anatomical labels. The greatest overall disagreement among the protocols is at the CA1/subiculum boundary, and disagreement across all structures is greatest in the anterior portion of the hippocampal formation relative to the body and tail.

Conclusions: The combined examination of the 21 protocols in the same dataset suggests possible strategies towards developing a harmonized subfield segmentation protocol and facilitates comparison between published studies.
Relaxed Simultaneous Tomographic Reconstruction and Segmentation with Class Priors for Poisson Noise

This work is a continuation of work on algorithms for simultaneous reconstruction and segmentation. In our previous work we developed an algorithm for data with Gaussian noise, and in that algorithm the coefficient matrix for the system is explicitly stored. We improve this algorithm in two ways: our new algorithm can handle Poisson noise in the data, and it can solve much larger problems since it does not store the matrix. We formulate this algorithm and test it on artificial test problems. Our results show that the algorithm performs well, and that we are able to produce reconstructions and segmentations with small errors.
Reliability in Measuring Head Related Transfer Functions of Hearing Aids

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Oticon A/S, Enskoholm Research Centre, Austrian Academy of Sciences
Authors: Harder, S. (Intern), Paulsen, R. R. (Intern), Larsen, M. (Ekstern), Laugesen, S. (Ekstern), Mihocic, M. (Ekstern), Majdak, P. (Ekstern)
Pages: 1064-1066
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Main Research Area: Technical/natural sciences
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Journal: Acta Acustica United With Acustica
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Scopus rating (2016): CiteScore 1.12 SJR 0.451 SNIP 0.834
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.617 SNIP 1.093 CiteScore 1.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.615 SNIP 1.071 CiteScore 0.89
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.597 SNIP 1.6 CiteScore 1.05
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.602 SNIP 0.963 CiteScore 0.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Simulation of GNSS reflected signals and estimation of position accuracy in GNSS-challenged environment

The paper describes the development and testing of a simulation tool, called QualiSIM. The tool estimates GNSS-based position accuracy based on a simulation of the environment surrounding the GNSS antenna, with a special focus on cityscape environments with large amounts of signal reflections from non-line-of-sight satellites. The signal reflections are implemented using the extended geometric path length of the signal path caused by reflections from the surrounding buildings. Based on real GPS satellite positions, simulated Galileo satellite positions, models of atmospheric effect on the satellite signals, designs of representative environments e.g. urban and rural scenarios, and a method to simulate reflection of satellite signals within the environment we are able to estimate the position accuracy given several prerequisites as described in the paper. The result is a modelling of the signal path from satellite to receiver, the satellite availability, the extended pseudoranges caused by signal reflection, and an estimate of the position accuracy based on a least squares adjustment of the extended pseudoranges. The paper describes the models and algorithms used and a verification test where the results of QualiSIM are compared with results from collection of real GPS data in an environment with much signal reflection.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Geodesy, KTH - Royal Institute of Technology
Authors: Jakobsen, J. (Intern), Jensen, A. B. O. (Ekstern), Nielsen, A. A. (Intern)
Pages: 47-56
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Geodetic Science
Volume: 5
Simultaneous tomographic reconstruction and segmentation with class priors

We consider tomographic imaging problems where the goal is to obtain both a reconstructed image and a corresponding segmentation. A classical approach is to first reconstruct and then segment the image; more recent approaches use a discrete tomography approach where reconstruction and segmentation are combined to produce a reconstruction that is identical to the segmentation. We consider instead a hybrid approach that simultaneously produces both a reconstructed image and segmentation. We incorporate priors about the desired classes of the segmentation through a Hidden Markov Measure Field Model, and we impose a regularization term for the spatial variation of the classes across neighbouring pixels. We also present an efficient implementation of our algorithm based on state-of-the-art numerical optimization algorithms. Simulation experiments with artificial and real data demonstrate that our combined approach can produce better results than the classical two-step approach.
Spatial Accuracy of Embedded Surface Coloring in Color 3D Printing

Recent years, the industrial market for full-color AM is growing rapidly. In the AM industry, most of the major technology providers are developing new systems with improved color capabilities and with improved materials. In the last 12 months alone, 5 new technology platforms have been revealed capable of full-color printing in polymers[1]. Industrial service providers increasingly expand their product-range of full colorprint services, and as of today, the industry for full-color parts has grown rapidly, into a million-dollar industry[2]. With a new market emerging at such pace, it is believed a necessity to consider a new surface-metrological issue. To what accuracy are colors embedded to the surface of geometries, with relation to where specified from input data? This paper investigate the accuracy of surface coloring, by adopting a well-known metrological approach from calibrating Coordinate Measurement Machines (CMM’s) and Machine Tools, that already has been transferred to be applicable for AM machine tools, [3] in order to determine the spatial accuracy of embedded color features to artifacts printed on a zCorp 650 color 3D Printer. The spatial color verification artifact is a flat plate with a series of checkerboard fields on the surface.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Manufacturing Engineering
Authors: Pedersen, D. B. (Intern), Hansen, H. N. (Intern), Eiriksson, E. R. (Intern)
Pages: 147-150
Publication date: 2015
Statistical selection of tide gauges for Arctic sea-level reconstruction

In this paper, we seek an appropriate selection of tide gauges for Arctic Ocean sea-level reconstruction based on a combination of empirical criteria and statistical properties (leverages). Tide gauges provide the only in situ observations of sea level prior to the altimetry era. However, tide gauges are sparse, of questionable quality, and occasionally contradictory in their sea-level estimates. Therefore, it is essential to select the gauges very carefully. In this study, we have established a reconstruction based on empirical orthogonal functions (EOFs) of sea-level variations for the period 1950-2010 for the Arctic Ocean, constrained by tide gauge records, using the basic approach of Church et al. (2004). A major challenge is the sparsity of both satellite and tide gauge data beyond what can be covered with interpolation, necessitating a time-variable selection of tide gauges and the use of an ocean circulation model to provide gridded time series of sea level. As a surrogate for satellite altimetry, we have used the Drakkar ocean model to yield the EOFs. We initially evaluate the tide gauges through empirical criteria to reject obvious outlier gauges. Subsequently, we evaluate the “influence” of each Arctic tide gauge on the EOF-based reconstruction through the use of statistical leverage and use this as an indication in selecting appropriate tide gauges, in order to procedurally identify poor-quality data while still including as much data as possible. To accommodate sparse or contradictory tide gauge data, careful preprocessing and regularization of the reconstruction model are found to make a substantial difference to the quality of the reconstruction and the ability to select appropriate tide gauges for a reliable reconstruction. This is an especially important consideration for the Arctic, given the limited amount of data available. Thus, such a tide gauge selection study can be considered a precondition for further studies of Arctic sea-level reconstruction.
Structured Light Scanning of Skin, Muscle and Fat

We investigate the quality of structured light 3D scanning on pig skin, muscle and fat. These particular materials are interesting in a number of industrial and medical use-cases, and somewhat challenging because they exhibit subsurface light scattering. Our goal therefor is to quantify the amount of error that various encoding strategies show, and propose an error correcting model, which can bring down the measurement bias considerably. Samples of raw and unprocessed pig tissue were used with the number of sampled surface points $N_{meat} = 1.2 \times 10^6$, $N_{skin} = 4.0 \times 10^6$ and $N_{fat} = 2.1 \times 10^6$ from 8 different pieces of tissue. With the standard N-step phase shifting method, the bias and RMS errors were found to be $0.45 \pm 0.22\text{mm}$ (muscle), $0.51 \pm 0.19\text{mm}$ (skin) and $0.14 \pm 0.16\text{mm}$ (fat). After applying a linear correction model containing view, light angles and point distances, the bias was almost completely removed on test data, and standard deviations slightly reduced. To our knowledge this is the first quantitative study of the measurement error of structured light with biological tissue.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Wilm, J. (Intern), Jensen, S. H. N. (Intern), Aanæs, H. (Intern)
Number of pages: 9
Publication date: 2015
Teach it Yourself - Fast Modeling of Industrial Objects for 6D Pose Estimation

In this paper, we present a vision system that allows a human to create new 3D models of novel industrial parts by placing the part in two different positions in the scene. The two shot modeling framework generates models with a precision that allows the model to be used for 6D pose estimation without loss in pose accuracy. We quantitatively show that our modeling framework reconstructs noisy but adequate object models with a mean RMS error at 2.7 mm, a mean standard deviation at 0.025 mm and a completeness of 70.3 % over all 14 reconstructed models, compared to the ground truth CAD models. In addition, the models are applied in a pose estimation application, evaluated with 37 different scenes with 61 unique object poses. The pose estimation results show a mean translation error on 4.97 mm and a mean rotation error on 3.38 degrees.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Southern Denmark, Danish Technological Institute
Authors: Sølund, T. (Intern), Rajeeth Savarimuthu, T. (Ekstern), Glent Buch, A. (Ekstern), Beck, A. B. (Ekstern), Krüger, N. (Ekstern), Aanæs, H. (Intern)
Pages: 289-302
Publication date: 2015

The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS)

In this paper we report the set-up and results of the Multimodal Brain Tumor Image Segmentation Benchmark (BRATS) organized in conjunction with the MICCAI 2012 and 2013 conferences. Twenty state-of-the-art tumor segmentation algorithms were applied to a set of 65 multi-contrast MR scans of low- and high-grade glioma patients – manually annotated by up to four raters – and to 65 comparable scans generated using tumor image simulation software. Quantitative evaluations revealed considerable disagreement between the human raters in segmenting various tumor sub-regions (Dice scores in the range 74-85%), illustrating the difficulty of this task. We found that different algorithms worked best for different sub-regions (reaching performance comparable to human inter-rater variability), but that no single algorithm ranked in the top for all subregions simultaneously. Fusing several good algorithms using a hierarchical majority vote yielded segmentations that consistently ranked above all individual algorithms, indicating remaining opportunities for further methodological improvements. The BRATS image data and manual annotations continue to be publicly available through an online evaluation system as an ongoing benchmarking resource.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Bern, Harvard Medical School, US National Institute of Health, Bern University Hospital, Aalto University, Massachusetts Institute of Technology, ETH Zurich
Authors: Menze, B. H. (Ekstern), Jakab, A. (Ekstern), Bauer, S. (Ekstern), Kalpathy-Cramer, J. (Ekstern), Farahani, K. (Ekstern), Kirby, J. (Ekstern), Burren, Y. (Ekstern), Porz, N. (Ekstern), Slotboom, J. (Ekstern), Wiest, R. (Ekstern), Van Leemput, K. (Intern)
Tissue Classification

Computational methods for automatically segmenting magnetic resonance images of the brain have seen tremendous advances in recent years. So-called tissue classification techniques, aimed at extracting the three main brain tissue classes (white matter, gray matter, and cerebrospinal fluid), are now well established. In their simplest form, these methods classify voxels independently based on their intensity alone, although much more sophisticated models are typically used in practice.

This article aims to give an overview of often-used computational techniques for brain tissue classification. Although other methods exist, we concentrate on Bayesian modeling approaches, in which generative image models are constructed and subsequently 'inverted' to obtain automated segmentations. This general framework encompasses a large number of segmentation methods, including those implemented in widely used software packages such as SPM, FSL, and FreeSurfer.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School
Authors: Van Leemput, K. (Intern), Puonti, O. (Intern)
Pages: 373-381
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Host publication information

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Volume: 1
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Main Research Area: Technical/natural sciences
DOIs: 10.1016/B978-0-12-397025-1.00308-0
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Transmission Near-Infrared (NIR) and Photon Time-of-Flight (PTOF) Spectroscopy in a Comparative Analysis of Pharmaceuticals.

We present a comprehensive study of the application of photon time-of-flight spectroscopy (PTOFS) in the wavelength range 1050–1350 nm as a spectroscopic technique for the evaluation of the chemical composition and structural properties of pharmaceutical tablets. PTOFS is compared to transmission near-infrared spectroscopy (NIRS). In contrast to transmission NIRS, PTOFS is capable of directly and independently determining the absorption and reduced scattering coefficients of the medium. Chemometric models were built on the evaluated absorption spectra for predicting tablet drug concentration. Results are compared to corresponding predictions built on transmission NIRS measurements. The predictive ability of PTOFS and transmission NIRS is comparable when models are based on uniformly distributed tablet sets. For non-uniform distribution of tablets based on particle sizes, the prediction ability of PTOFS is better than that of transmission NIRS. Analysis of reduced scattering spectra shows that PTOFS is able to characterize tablet microstructure and manufacturing process parameters. In contrast to the chemometric pseudovariables provided by transmission NIRS, PTOFS provides physically meaningful quantities such as scattering strength and slope of particle size. The ability of PTOFS to quantify the reduced scattering spectra, together with its robustness in predicting drug content, makes it suitable for such evaluations in the pharmaceutical industry.

General information

State: Published
Organisations: Department of Photonics Engineering, Diode Lasers and LED Systems, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, AstraZeneca Sweden, Lund University
Understanding uncertainty propagation in life cycle assessments of waste management systems

Uncertainty analysis in Life Cycle Assessments (LCAs) of waste management systems often results obscure and complex, with key parameters rarely determined on a case-by-case basis. The paper shows an application of a simplified approach to uncertainty coupled with a Global Sensitivity Analysis (GSA) perspective on three alternative waste management systems for Danish single-family household waste. The approach provides a fast and systematic method to select the most important parameters in the LCAs, understand their propagation and contribution to uncertainty.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Bisinella, V. (Intern), Conradsen, K. (Intern), Christensen, T. H. (Intern), Astrup, T. F. (Intern)
Number of pages: 8
Publication date: 2015

Using Motion Tracking to Detect Spontaneous Movements in Infants

We study the characteristics of infants’ spontaneous movements, based on data obtained from a markerless motion tracking system. From the pose data, the set of features are generated from the raw joint-angles of the infants and different classifiers are trained and evaluated using annotated data. Furthermore, we look at the importance of different features and outline the most significant features for detecting spontaneous movements of infants. Using these findings for further analysis of infants’ movements, this might be used to identify infants in risk of cerebral palsy.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Technical University of Denmark
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Number of pages: 8
Pages: 410-417
Publication date: 2015
**VirtualTable: a projection augmented reality game**

VirtualTable is a projection augmented reality installation where users are engaged in an interactive tower defense game. The installation runs continuously and is designed to attract people to a table, which the game is projected onto. Any number of players can join the game for an optional period of time. The goal is to prevent the virtual stylized soot balls, spawning on one side of the table, from reaching the cheese. To stop them, the players can place any kind of object on the table, that then will become part of the game. Depending on the object, it will become either a wall, an obstacle for the soot balls, or a tower, that eliminates them within a physical range. The number of enemies is dependent on the number of objects in the field, forcing the players to use strategy and collaboration and not the sheer number of objects to win the game.

**General information**

State: Published

Organisations: IT Service, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Mathematics, Statistics and Data Analysis


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**Analysis of micro-structure in raw and heat treated meat emulsions from multimodal X-ray microtomography**

This study presents a novel non-destructive X-ray technique for analyzing meat emulsions before and after heat treatment. The method is based on X-ray grating-interferometry where three complementary imaging modalities are obtained simultaneously measuring the absorption, refraction and scattering properties of the sample. Enhanced contrast capabilities of this X-ray technique makes studies on materials with similar attenuation properties possible. The emulsion samples were imaged both in a raw and cooked state. Additionally, different fat types were used in the emulsions in order to compare microstructural differences when either pork fat or sunflower oil was added. From the reconstructed tomograms the different constituents in the emulsions were segmented using a multivariate segmentation method. From this, a quantitative analysis was performed between the different samples, determining properties such as percent object volumes, porosity, average structure thickness and cooking loss. The grating-based X-ray technique and multivariate segmentation made the analysis of the microstructure possible which further gives insight to how both heat treatment, and the use of different lipid types, affect the final protein network quality.

Industrial relevance: Meat emulsions have previously been thoroughly studied, and the use of various fat substitutes and protein stabilizers has been investigated. The grating-based multimodal X-ray tomography method presented here is a feasible method to investigate the microstructural changes induced by heat treatment. It provides high-resolution three dimensional spatial information and in contrast to 2D imaging methods, quantitative parameters can be extracted by image analysis for the entire sample volume. Additionally, the non-destructive method allows for imaging the same sample before and after cooking.

**General information**
2D Static Light Scattering for Dairy Based Applications

Throughout this thesis we investigate a recently introduced optical technique denoted 2D static light scattering (2DSLS). The technique is remote sensing, non-invasive, highly flexible, and appears to be well suited for in-line process control. Moreover, the output signal contains contributions from several different optical phenomena, which can be utilised to provide information on chemical composition and underlying microstructure of an investigated sample.

The main goal of this thesis is to provide an exploratory study of the 2DSLS technique in relation to dairy based applications. This includes getting an understanding of the various parameters in the setup as well as understanding the output signal in terms of potential and limitations. Furthermore, suitable ways of quantifying the signal are investigated. Here, both established physical models and statistical descriptions of the signal are evaluated and discussed.

There is a major emphasis on using 2DSLS to discriminate between different protein microstructures in yogurt products. This potentially allows for process control, in relation to microstructure, during yogurt manufacture. As microstructure is critical for consumer acceptability, this specific process control can be highly beneficial. To provide suitable reference measures on the actual microstructure, we investigate how to quantify micrographs of yogurts objectively. We provide a comparative study, that includes a broad range of different image texture descriptors.

3D facial landmarks: Inter-operator variability of manual annotation

Background
Manual annotation of landmarks is a known source of variance, which exist in all fields of medical imaging, influencing the accuracy and interpretation of the results. However, the variability of human facial landmarks is only sparsely addressed in the current literature as opposed to e.g. the research fields of orthodontics and cephalometrics. We present a full facial 3D annotation procedure and a sparse set of manually annotated landmarks, in effort to reduce operator time and minimize the variance.

Method
Facial scans from 36 voluntary unrelated blood donors from the Danish Blood Donor Study was randomly chosen. Six operators twice manually annotated 73 anatomical and pseudo-landmarks, using a three-step scheme producing a dense point correspondence map. We analyzed both the intra- and inter-operator variability, using mixed-model ANOVA. We then compared four sparse sets of landmarks in order to construct a dense correspondence map of the 3D scans with a minimum point variance.

Results
The anatomical landmarks of the eye were associated with the lowest variance, particularly the center of the pupils. Whereas points of the jaw and eyebrows have the highest variation. We see marginal variability in regards to intra-operator and portraits. Using a sparse set of landmarks (n=14), that capture the whole face, the dense point mean variance was reduced from 1.92 to 0.54 mm.

Conclusion
The inter-operator variability was primarily associated with particular landmarks, where more leniently landmarks had the highest variability. The variables embedded in the portray and the reliability of a trained operator did only have marginal influence on the variability. Further, using 14 of the annotated landmarks we were able to reduced the variability and create a dense correspondeces mesh to capture all facial features.
A Cautionary Analysis of STAPLE Using Direct Inference of Segmentation Truth

In this paper we analyze the properties of the well-known segmentation fusion algorithm STAPLE, using a novel inference technique that analytically marginalizes out all model parameters. We demonstrate both theoretically and empirically that when the number of raters is large, or when consensus regions are included in the model, STAPLE devolves into thresholding the average of the input segmentations. We further show that when the number of raters is small, the STAPLE result may not be the optimal segmentation truth estimate, and its model parameter estimates might not reflect the individual raters' actual segmentation performance. Our experiments indicate that these intrinsic weaknesses are frequently exacerbated by the presence of undesirable global optima and convergence issues. Together these results cast doubt on the soundness and usefulness of typical STAPLE outcomes.

Accurate and Simple Calibration of DLP Projector Systems

Much work has been devoted to the calibration of optical cameras, and accurate and simple methods are now available which require only a small number of calibration targets. The problem of obtaining these parameters for light projectors has not been studied as extensively and most current methods require a camera and involve feature extraction from a known projected pattern. In this work we present a novel calibration technique for DLP Projector systems based on phase shifting profilometry projection onto a printed calibration target. In contrast to most current methods, the one presented here does not rely on an initial camera calibration, and so does not carry over the error into projector calibration. A radial interpolation scheme is used to convert features coordinates into projector space, thereby allowing for a very accurate procedure. This allows for highly accurate determination of parameters including lens distortion. Our implementation acquires printed planar calibration scenes in less than 1s. This makes our method both fast and convenient. We evaluate our method in terms of reprojection errors and structured light image reconstruction quality.
Addressing Grazing Angle Reflections in Phong Models

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Advising students in technical projects - recognizing problem scenarios

In this paper, we consider the advisor's role during the technical work and the thesis preparation for a student in the final phase of a course of study in an engineering education. We initially claim that there is a marked difference between the learning that takes place in regular course work and the learning ensuing from project work. Concrete differences include that

• unlike the a-priori fixed curriculum of regular courses, an important aspect of a project is to define and scientifically formulate the problem itself, in which the student is to be engaged.
• projects are carried out individually or in very small groups. For an interesting project, the precise outcome cannot be known in advance.
• The flexible and individual nature of each project requires that time must be carefully divided and managed between defining the problem, seeking information, implementing solutions and presenting results.

While students work hard during projects and advisors will do their best to support the students' activities, it is not uncommon that a student fails to meet either his or her own expectations and/or those of the advisor. Occasionally, this is true also of students who perform brilliantly in regular courses. The goal of this paper is to relate the authors' experiences and investigations into the project advisory process and to provide recommendations for other engineering educators.

After an initial discussion of a typical engineering project advisory process, we review a number of representative projects (abstracted and anonymized) and analyze conditions under which a failure to meet or match expectations is likely to arise. This leads us to a small number of scenarios, where a student is likely to under-perform. Common to these scenarios is a lack of balance between the necessary activities in an engineering project. As our main contribution, we investigate and categorize these imbalances leading to the aforementioned scenarios. Finally, we distill suggestions for best project advisory practices.

Alzheimer's Disease Diagnostic Performance of a Multi-Atlas Hippocampal Segmentation Method using the Harmonized Hippocampal Protocol

PURPOSE

Hippocampal volumetry is the most widely used structural MRI biomarker of Alzheimer's disease (AD), and state-of-the-art, automatic hippocampal segmentation can be obtained using longitudinal FreeSurfer. In this study, we compare the
diagnostic AD performance of a single time point, multi-atlas method using the Harmonized Hippocampal Protocol (HHP) to FreeSurfer (FS).

METHOD AND MATERIALS
Baseline and month 12 MRI scans from the “complete annual year 2 visits” 1.5-T standardized ADNI dataset were used [169 normal controls (NC), 234 mild cognitive impaired (MCI), 101 AD]. A multi-atlas, affine registration, patch-based segmentation method (MRP) using 40 HHP segmentations in the atlas (12 NC, 11 MCI, 17 AD) was applied to segment the hippocampi. Static- and longitudinal FS (v5.1.0, default parameters) were also applied to segment the hippocampi. Atrophy rate calculated as percent volume change from baseline to month 12 was estimated for the three methods, and diagnostic performance was evaluated using the area under the receiver operating characteristic curve (AUC) of pairwise diagnostic group comparisons.

RESULTS
Mean (SD) atrophy rates were as follows (MRP / static FS / longitudinal FS): NC -0.86 (2.46) / -1.39 (5.41) / -1.63 (2.54), MCI -2.38 (3.28) / -3.69 (5.48) / -3.25 (3.53), AD -4.23 (3.07) / -4.29 (5.32) / -4.83 (3.74). Diagnostic performances were as follows (AUC; MRP / static FS / longitudinal FS): NC vs. MCI 0.65 / 0.67 / 0.64, NC vs. AD 0.80 / 0.69 / 0.76, MCI vs. AD 0.66 / 0.53 / 0.62. The MRP AUC was significantly larger (DeLong) than the static FS AUC for NC vs. AD and MCI vs. AD. In the remaining pairwise group comparisons, MRP AUCs did not differ significantly from FS AUCs.

CONCLUSION
The MRP method discriminated AD from either NC or MCI significantly better than static FS, and it was as good as longitudinal FS, which exploits information from both time points simultaneously. Moreover, the standard deviation of the atrophy rate was comparable to that of longitudinal FS, emphasizing longitudinal robustness of segmentations of the proposed method. The combination of MRP and HHP is a robust and fast alternative to FreeSurfer, especially in a setting with many time points.

An Inference Language for Imaging
We introduce iLang, a language and software framework for probabilistic inference. The iLang framework enables the definition of directed and undirected probabilistic graphical models and the automated synthesis of high performance inference algorithms for imaging applications. The iLang framework is composed of a set of language primitives and of an inference engine based on a message-passing system that integrates cutting-edge computational tools, including proximal algorithms and high performance Hamiltonian Markov Chain Monte Carlo techniques. A set of domain-specific highly optimized GPU-accelerated primitives specializes iLang to the spatial data-structures that arise in imaging applications. We illustrate the framework through a challenging application: spatio-temporal tomographic reconstruction with compressive sensing.

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Arctic sea-level reconstruction analysis using recent satellite altimetry
We present a sea-level reconstruction for the Arctic Ocean using recent satellite altimetry data. The model, forced by historical tide gauge data, is based on empirical orthogonal functions (EOFs) from a calibration period; for this purpose, newly retracked satellite altimetry from ERS-1 and -2 and Envisat has been used. Despite the limited coverage of these datasets, we have made a reconstruction up to 82 degrees north for the period 1950–2010. We place particular emphasis on determining appropriate preprocessing for the tide gauge data, and on validation of the model, including the ability to reconstruct known data. The relationship between the reconstruction and climatic variables, such as atmospheric pressure, and climate oscillations, including the Arctic Oscillation (AO), is examined.

Assessment of algorithms for mitosis detection in breast cancer histopathology images
The proliferative activity of breast tumors, which is routinely estimated by counting of mitotic figures in hematoxylin and eosin stained histology sections, is considered to be one of the most important prognostic markers. However, mitosis counting is laborious, subjective and may suffer from low inter-observer agreement. With the wider acceptance of whole slide images in pathology labs, automatic image analysis has been proposed as a potential solution for these issues. In this paper, the results from the Assessment of Mitosis Detection Algorithms 2013 (AMIDA13) challenge are described. The challenge was based on a dataset consisting of 12 training and 11 testing subjects, with more than one thousand annotated mitotic figures by multiple observers. Short descriptions and results from the evaluation of eleven methods are presented. The top performing method has an error rate that is comparable to the inter-observer agreement among pathologists.
A Structured Light Scanner for Hyper Flexible Industrial Automation

A current trend in industrial automation implies a need for doing automatic scene understanding, from optical 3D sensors, which in turn imposes a need for a lightweight and reliable 3D optical sensor to be mounted on a collaborative robot e.g., Universal Robot UR5 or Kuka LWR. Here, we empirically evaluate the feasibility of structured light scanners for this purpose, by presenting a system optimized for this task. The system incorporates several recent advances in structured light scanning, such as Large-Gap Gray encoding for dealing with defocusing, automatic creation of illumination masks for noise removal, as well as employing a multi-exposure approach dealing with different surface reflectance properties. In addition to this, we investigate expanding the traditional structured light setup to using three cameras, instead of one or two. Also, a novel method for fusing multiple exposures and camera pairs is given. We present an in-depth evaluation, that lead us to conclude, that this setup performs well on tasks relevant for an industrial environment, where many metallic and other surfaces with difficult reflectance properties are in abundance. We demonstrate, that the added components contribute to the robustness of the system. Hereby, we demonstrate that structured light scanning is a technology well suited for hyper flexible industrial automation, by proposing an appropriate system.

A Unified Approach to Diffusion Direction Sensitive Slice Registration and 3-D DTI Reconstruction From Moving Fetal Brain Anatomy

This paper presents an approach to 3-D diffusion tensor image (DTI) reconstruction from multi-slice diffusion weighted (DW) magnetic resonance imaging acquisitions of the moving fetal brain. Motion scatters the slice measurements in the spatial and spherical diffusion domain with respect to the underlying anatomy. Previous image registration techniques have been described to estimate the between slice fetal head motion, allowing the reconstruction of 3D a diffusion estimate on a regular grid using interpolation. We propose Approach to Unified Diffusion Sensitive Slice Alignment and Reconstruction (AUDISSAR) that explicitly formulates a process for diffusion direction sensitive DW-slice-to-DTI-volume alignment. This also incorporates image resolution modeling to iteratively deconvolve the effects of the imaging point spread function using the multiple views provided by thick slices acquired in different anatomical planes. The algorithm is implemented using a multi-resolution iterative scheme and multiple real and synthetic data are used to evaluate the
performance of the technique. An accuracy experiment using synthetically created motion data of an adult head and an
experiment using synthetic motion added to sedated fetal monkey dataset show a significant improvement in motion-
trajectory estimation compared to current state-of-the-art approaches. The performance of the method is then evaluated
on challenging but clinically typical in utero fetal scans of four different human cases, showing improved rendition of
cortical anatomy and extraction of white matter tracts. While the experimental work focuses on DTI reconstruction
(second-order tensor model), the proposed reconstruction framework can employ any 5-D diffusion volume model that can
be represented by the spatial parameterizations of an orientation distribution function.

**General information**

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Automated Hippocampal Segmentation using new standardized manual segmentations from the Harmonized Hippocampal Protocol

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Automatic balancing of 3D models
3D printing technologies allow for more diverse shapes than are possible with molds and the cost of making just one single object is negligible compared to traditional production methods. However, not all shapes are suitable for 3D print. One of the remaining costs is therefore human time spent on analyzing and editing a shape in order to ensure that it is fit for production. In this paper, we seek to automate one of these analysis and editing tasks, namely improving the balance of a model to ensure that it stands. The presented method is based on solving an optimization problem. This problem is solved by creating cavities of air and distributing dense materials inside the model. Consequently, the surface is not deformed. However, printing materials with significantly different densities is often not possible and adding cavities of air is not enough to make the model balance. Consequently, in these cases, we will apply a rotation of the object which only deforms the shape a little near the base. No user input is required but it is possible to specify manufacturing constraints related to specific 3D print technologies. Several models have successfully been balanced and printed using both polyjet and fused deposition modeling printers.

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A voxel-based investigation for MRI-only radiotherapy of the brain using ultra short echo times

Radiotherapy (RT) based on magnetic resonance imaging (MRI) as the only modality, so-called MRI-only RT, would remove the systematic registration error between MR and computed tomography (CT), and provide co-registered MRI for assessment of treatment response and adaptive RT. Electron densities, however, need to be assigned to the MRI images for dose calculation and patient setup based on digitally reconstructed radiographs (DRRs). Here, we investigate the geometric and dosimetric performance for a number of popular voxel-based methods to generate a so-called pseudo CT (pCT).
Five patients receiving cranial irradiation, each containing a co-registered MRI and CT scan, were included. An ultra short echo time MRI sequence for bone visualization was used. Six methods were investigated for three popular types of voxel-based approaches; (1) threshold-based segmentation, (2) Bayesian segmentation and (3) statistical regression. Each approach contained two methods. Approach 1 used bulk density assignment of MRI voxels into air, soft tissue and bone based on logical masks and the transverse relaxation time T2 of the bone. Approach 2 used similar bulk density assignments with Bayesian statistics including or excluding additional spatial information. Approach 3 used a statistical regression correlating MRI voxels with their corresponding CT voxels. A similar photon and proton treatment plan was generated for a target positioned between the nasal cavity and the brainstem for all patients. The CT agreement with the pCT of each method was quantified and compared with the other methods geometrically and dosimetrically using both a number of reported metrics and introducing some novel metrics.

The best geometrical agreement with CT was obtained with the statistical regression methods which performed significantly better than the threshold and Bayesian segmentation methods (excluding spatial information). All methods agreed significantly better with CT than a reference water MRI comparison. The mean dosimetric deviation for photons and protons compared to the CT was about 2% and highest in the gradient dose region of the brainstem. Both the threshold based method and the statistical regression methods showed the highest dosimetric agreement.

Generation of pCTs using statistical regression seems to be the most promising candidate for MRI-only RT of the brain. Further, the total amount of different tissues needs to be taken into account for dosimetric considerations regardless of their correct geometrical position.
Body-Part Tracking of Infants

Motion tracking is a widely used technique to analyze and measure adult human movement. However, these methods cannot be transferred directly to motion tracking of infants due to the big differences in the underlying human model. However, motion tracking of infants can be used for automatic analysis of infant development and might be able to tell something about possible motor disabilities such as cerebral palsy. In this paper, we address markerless 3D body part detection of infants using a widely available depth sensor and discuss some of the major challenges that arise. We present a method to detect and identify a set of the anatomical extremities and the results are evaluated based on manually annotated 3D positions.

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Broadband optical characterization of material properties

Optical inspection of material properties is of great interest to industry because it can perform objective and non-invasive characterisation of large sample quantities. This may be used in various ways to lower production costs and improve product quality. In this thesis the objective has been to develop and investigate the applicability of optical broadband characterization techniques in industrially relevant production process. Both combined broad and high resolution techniques have the potential to provide important information on scattering properties related to particle size distributions, as well as details of the absorption spectrum which relate to chemical composition.

The thesis focuses on two production process from the food industry. The first process is from the dairy industry where discrimination between chemical and structural properties is of importance. To explore the applicability of optical techniques for this purpose, the fermentation of milk into yogurt has been used as a model system. Studies have been conducted on commercially available products, but also of on-line measurement of the fermentation process. The second process is from the aquaculture industry, quantification of the fish feed additive astaxanthin has been investigated. A measurement campaign has been carried out on a series of pellets specially produced for the purpose.

To investigate these process, the following three measurement techniques have been developed and applied. (I) A camera based inspection system for spectrally resolved Static Light Scattering (SLS). (II) Photon Time-of-Flight (PToF) spectroscopy, which is a state of the art technique for characterization of turbid media. (III) A new hyperspectral imaging system based on full-field illumination by diffuse laser light. This thesis reports on the design and operation of the different measurement techniques together with the necessary theoretical background for the industrial applications.

For the purpose of milk fermentation this work has demonstrated that the reduced scattering properties of milk change significantly throughout the fermentation process. It has also been shown that the optical inspection methods sense changes to structural properties before any are detected by traditional mechanical rheology. Finally, the developed hyperspectral imaging system was used to quantify the content of astaxanthin in fish feed, and performed at an equal level to a state of the art multi-spectral vision system.
Calibrated image-derived input functions for the determination of the metabolic uptake rate of glucose with $[^{18}F]$-FDG PET

We investigated the use of a simple calibration method to remove bias in previously proposed approaches to image-derived input functions (IDIFs) when used to calculate the metabolic uptake rate of glucose ($K_m$) from dynamic $[^{18}F]$-FDG PET scans of the thigh. Our objective was to obtain nonbiased, low-variance $K_m$ values without blood sampling.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital, University of Copenhagen
Authors: Christensen, A. N. (Intern), Reichkendler, M. H. (Ekstern), Larsen, R. (Intern), Auerbach, P. (Ekstern), Højgaard, L. (Ekstern), Nielsen, H. B. (Ekstern), Ploug, T. (Ekstern), Stallknecht, B. (Ekstern), Holm, S. (Ekstern)
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.618 SNIP 0.697 CiteScore 1.42
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.699 SNIP 0.818 CiteScore 1.53
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.721 SNIP 0.808 CiteScore 1.68
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.615 SNIP 0.748 CiteScore 1.41
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.641 SNIP 0.782 CiteScore 1.41
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.601 SNIP 0.951 CiteScore 1.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.55 SNIP 0.627
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.491 SNIP 0.742
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.549 SNIP 0.752
Can We Find Organic Materials in Food Using X-rays?

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis
Authors: Emerson, M. J. (Intern), Einarsdottir, H. (Intern), Clemmensen, L. K. H. (Intern), Ersbøll, B. K. (Intern)
Number of pages: 1
Publication date: 2014
Main Research Area: Technical/natural sciences
Electronic versions: PosterFAIM.pdf
Source: PublicationPreSubmission
Source-ID: 127748272
Publication: Research - peer-review › Poster – Annual report year: 2014

Change detection in a time series of polarimetric SAR data
A test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated probability of finding a smaller value of the test statistic is introduced. Unlike tests based on pairwise comparisons between all temporally consecutive acquisitions the new omnibus test statistic and the probability measure successfully detects change in two short series of L- and C-band polarimetric EMISAR data.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Skriver, H. (Intern)
Number of pages: 4
Pages: 136-139
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Title of host publication: Proceedings of the 2014 conference on Big Data from Space (BiDS’14)
Publisher: European Space Agency
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 103646227
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014
Change detection in polarimetric SAR data over several time points
A test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution is introduced. The test statistic is applied successfully to detect change in C-band EMISAR polarimetric SAR data over four time points.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Skriver, H. (Intern)
Pages: 4540-4543
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Host publication information
Title of host publication: Proceedings of the IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2014
Publisher: IEEE
ISBN (Print): 978-1-4799-5775-0
Main Research Area: Technical/natural sciences
Geoscience
DOIs: 10.1109/IGARSS.2014.6947502
Source: FindIt
Source-ID: 272557531
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Characterization of graphite nodules in thick-walled ductile cast iron

General information
State: Published
Authors: Mukherjee, K. (Intern), Fæster, S. (Intern), Dahl, A. B. (Intern), Sturlason, A. (Ekstern)
Pages: 405-410
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Main Research Area: Technical/natural sciences

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BFI (2014): BFI-level 1
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ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Chemical imaging and solid state analysis at compact surfaces using UV imaging
Fast non-destructive multi-wavelength UV imaging together with multivariate image analysis was utilized to visualize distribution of chemical components and their solid state form at compact surfaces. Amorphous and crystalline solid forms of the antidiabetic compound glibenclamide, and microcrystalline cellulose together with magnesium stearate as excipients were used as model materials in the compacts. The UV imaging based drug and excipient distribution was in good agreement with hyperspectral NIR imaging. The UV wavelength region can be utilized in distinguishing between glibenclamide and excipients in a non-invasive way, as well as mapping the glibenclamide solid state form. An exploratory data analysis supported the critical evaluation of the mapping results and the selection of model parameters for the chemical mapping. The present study demonstrated that the multi-wavelength UV imaging is a fast process analytical technique with the potential for real-time monitoring of critical quality attributes.
Combined shape and topology optimization for minimization of von Mises Stress

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Department of Mechanical Engineering, Solid Mechanics, University of Illinois at Urbana-Champaign
Authors: Christiansen, A. N. (Intern), Tortorelli, D. A. (Ekstern), Aage, N. (Intern), Sigmund, O. (Intern)
Number of pages: 2
Publication date: 2014
Main Research Area: Technical/natural sciences
Electronic versions:
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Source-ID: 101531171
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2014

Commentary to 'Application of calibrated image-derived input function to a clinical protocol'.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Christensen, A. N. (Intern)
Pages: 1189-1190
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Main Research Area: Technical/natural sciences

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CUDArray: CUDA-based NumPy

This technical report introduces CUDArray – a CUDA-accelerated subset of the NumPy library. The goal of CUDArray is to combine the ease of development from NumPy with the computational power of Nvidia GPUs in a lightweight and extensible framework. Since the motivation behind CUDArray is to facilitate neural network programming, CUDArray extends NumPy with a neural network submodule. This module has both a CPU and a GPU back-end to allow for experiments without requiring a GPU.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Larsen, A. B. L. (Intern)
Number of pages: 5
Publication date: 2014
Dictionary Snakes

Visual cues like texture, color and context make objects appear distinct from the surroundings, even without gradients between regions. Texture-rich objects are often difficult to segment because algorithms need advanced features which are unique for the image. In this paper we suggest a method for image segmentation that operates without training data. Our method is based on a probabilistic dictionary of image patches coupled with a deformable model inspired by snakes and active contours without edges. We separate the image into two classes based on the information provided by the evolving curve, which moves according to the probabilistic information obtained from the dictionary. Initially, the image patches are assigned to the nearest dictionary element, where the image is sampled at each pixel such that patches overlap. The curve divides the image into an inside and an outside region allowing us to estimate the pixel-wise probability of the dictionary elements. In each iteration we evolve the curve and update the probabilities, which merges similar texture patterns and pulls dissimilar patterns apart. We experimentally evaluate our approach, and show how textured objects are precisely segmented without any prior assumptions about image features. In addition, a texture probability image is obtained.

Directional Dipole Model for Subsurface Scattering

Rendering translucent materials using Monte Carlo ray tracing is computationally expensive due to a large number of subsurface scattering events. Faster approaches are based on analytical models derived from diffusion theory. While such analytical models are efficient, they miss out on some translucency effects in the rendered result. We present an improved analytical model for subsurface scattering that captures translucency effects present in the reference solutions but remaining absent with existing models. The key difference is that our model is based on ray source diffusion, rather than point source diffusion. A ray source corresponds better to the light that refracts through the surface of a translucent material. Using this ray source, we are able to take the direction of the incident light ray and the direction toward the point of emergence into account. We use a dipole construction similar to that of the standard dipole model, but we now have positive and negative ray sources with a mirrored pair of directions. Our model is as computationally efficient as existing models while it includes single scattering without relying on a separate Monte Carlo simulation, and the rendered images are significantly closer to the references. Unlike some previous work, our model is fully analytic and requires no precomputation.
Rendering, BSSRDF, diffusion dipole, radiative transfer, subsurface scattering, translucent materials, turbid media
DLP technology application: 3D head tracking and motion correction in medical brain imaging

In this paper we present a novel sensing system, robust Near-infrared Structured Light Scanning (NIRSL) for three-dimensional human model scanning application. Human model scanning due to its nature of various hair and dress appearance and body motion has long been a challenging task. Previous structured light scanning methods typically emitted visible coded light patterns onto static and opaque objects to establish correspondence between a projector and a camera for triangulation. In the success of these methods rely on scanning objects with proper reflective surface for visible light, such as plaster, light colored cloth. Whereas for human model scanning application, conventional methods suffer from low signal to noise ratio caused by low contrast of visible light over the human body. The proposed robust NIRSL, as implemented with the near infrared light, is capable of recovering those dark surfaces, such as hair, dark jeans and black shoes under visible illumination. Moreover, successful structured light scan relies on the assumption that the subject is static during scanning. Due to the nature of body motion, it is very time sensitive to keep this assumption in the case of human model scan. The proposed sensing system, by utilizing the new near-infrared capable high speed LightCrafter DLP projector, is robust to motion, provides accurate and high resolution three-dimensional point cloud, making our system more efficient and robust for human model reconstruction. Experimental results demonstrate that our system is effective and efficient to scan real human models with various dark hair, jeans and shoes, robust to human body motion and produces accurate and high resolution 3D point cloud.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Authors: Olesen, O. V. (Intern), Wilm, J. (Intern), Paulsen, R. R. (Intern), Højgaard, L. (Ekstern), Larsen, R. (Intern)
Number of pages: 11
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BFI (2016): BFI-level 1
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.187 SNIP 0.224 CiteScore 0.3
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.188 SNIP 0.231 CiteScore 0.3
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.2 SNIP 0.259 CiteScore 0.26
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.194 SNIP 0.243 CiteScore 0.27
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Erratum to: Interesting Interest Points

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Aanæs, H. (Intern), Dahl, A. L. (Intern), Kim, S. P. (Ekstern)
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 11.06 SJR 8.269 SNIP 5.054
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.726 SNIP 4.329 CiteScore 6.81
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.834 SNIP 4.735 CiteScore 6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.767 SNIP 5.083 CiteScore 7.59
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Evaluation of the ID220 single photon avalanche diode for extended spectral range of photon time-of-flight spectroscopy

This paper describes the performance of the ID220 single photon avalanche diode for single photon counting, and investigates its performance for photon time-of-flight (PToF) spectroscopy. At first this report will serve as a summary to the group for PToF spectroscopy at the Department of Physics, Lund University (Sweden) together with ID Quantique Inc. (Geneve, Switzerland). As such, the report does not give an introduction to PToF spectroscopy, which may be found on the Doctoral on the topic [2, 18, 1]. The report focuses on a description of the detectors ability to measure the PToF distribution of infrared light.

First, a motivation for using the ID220 for measuring PToF distribution is given, followed by a brief description of the experimental setup in which the detector was characterized. Following this, the quantification of delay using cross correlation between PToF distributions is described. This allows the changes in delay and shape to be characterized. A technique for reducing measurement artefacts by lowering the repetition rate of the light source is also investigated. Lastly, the applicability of the detector for PTOF spectroscopy is discussed and conclusions drawn about its suitability for this application.

General information
State: Published
Authors: Nielsen, O. H. A. (Intern), Dahl, A. B. (Intern), Anderson-Engels, S. (Ekstern), Nielsen, F. D. (Ekstern), Thomsen, C. L. (Ekstern), Khoptyar, D. (Ekstern)
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Original language: English
Genus zero graph segmentation: Estimation of intracranial volume

The intracranial volume (ICV) in children with premature fusion of one or more sutures in the calvaria is of interest due to the risk of increased intracranial pressure. Challenges for automatic estimation of ICV include holes in the skull e.g. the foramen magnum and fontanelles. In this paper, we present a fully automatic 3D graph-based method for segmentation of the ICV in non-contrast CT scans. We reformulate the ICV segmentation problem as an optimal genus 0 segmentation problem in a volumetric graph. The graph is the result of a volumetric spherical subsampling. The equidistantly sampled data points are connected using Delaunay tetrahedralisation creating a highly connected neighborhood. A Markov Random Field (MRF) is constructed on the graph with probabilities learned from an Expectation Maximisation algorithm matching a Mixture of Gaussians to the data. The result of the MRF segmentation is compared to manual segmentations performed by an expert. We have achieved very high Dice scores ranging from 98.14% to 99.00%, while volume deviation from the manual segmentation ranges from 0.7% to 3.7%. The Hausdorff distance, which shows the maximum error from automatic to manual segmentation, ranges from 4.73 to 9.81 mm. Since this is sensitive to single error, we have also found the 95% Hausdorff distance, which ranges from 1.10 to 3.65 mm. The segmentation is very consistent with the reference and differs only in difficult areas, where it seems that our method is much more slice-wise consistent than a manual segmentation. The proposed method is expected to perform well for other volumetric segmentations.
HEp-2 Cell Classification Using Shape Index Histograms With Donut-Shaped Spatial Pooling

We present a new method for automatic classification of indirect immunofluorescence images of HEp-2 cells into different staining pattern classes. Our method is based on a new texture measure called shape index histograms that captures second-order image structure at multiple scales. Moreover, we introduce a spatial decomposition scheme which is radially symmetric and suitable for cell images. The spatial decomposition is performed using donut-shaped pooling regions of varying sizes when gathering histogram contributions. We evaluate our method using both the ICIP 2013 and the ICPR 2012 competition datasets. Our results show that shape index histograms are superior to other popular texture descriptors for HEp-2 cell classification. Moreover, when comparing to other automated systems for HEp-2 cell classification we show that shape index histograms are very competitive; especially considering the relatively low complexity of the method.
Bioengineering, Computing and Processing, Accuracy, Cell classification, Feature extraction, feature histograms, Histograms, Indexes, indirect immunofluorescence, Shape, shape index, Shape measurement, spatial pooling, texture description, Vectors

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10.1109/TMI.2014.2318434

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Source-ID: 268665792
Publication: Research - peer-review › Journal article – Annual report year: 2014
Hyperspectral imaging based on diffused laser light for prediction of astaxanthin coating concentration

We present a study on predicting the concentration level of synthetic astaxanthin in fish feed pellet coating using multi- and hyperspectral image analysis. This was done in parallel using two different vision systems. A new instrument for hyperspectral imaging, the SuperK setup, using a super-continuum laser as the light source was introduced. Furthermore, a parallel study with the commercially available multispectral VideometerLab imaging system was performed. The SuperK setup used 113 spectral bands (455–1,015 nm), and the VideometerLab used 20 spectral bands (385–1,050 nm). To predict the astaxanthin concentration from the spectral image data, the synthetic astaxanthin content in the pellets was measured with the established standard technique; high-pressure liquid chromatography (HPLC). Regression analysis was done using partial least squares regression (PLSR) and the sparse regression method elastic net (EN). The ratio of standard error of prediction (RPD) is the ratio between the standard deviation of the reference values and the prediction error, and for both PLSR and EN both devices gave RPD values between 4 and 24, and with mean prediction error of 1.4–8.0 parts per million of astaxanthin concentration. The results show that it is possible to predict the synthetic astaxanthin concentration in the coating well enough for quality control using both multi- and hyperspectral image analysis, while the SuperK setup performs with higher accuracy than the VideometerLab device for this particular problem. The spectral resolution made it possible to identify the most significant spectral regions for detection of astaxanthin. The results also imply that the presented methods can be used in general for quality inspection of various coating substances using similar coating methods.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Food Institute, Division of Industrial Food Research, Division of Toxicology and Risk Assessment, Statistics and Data Analysis
Authors: Ljungqvist, M. G. (Intern), Nielsen, O. H. A. (Intern), Frosch, S. (Intern), Nielsen, M. E. (Intern), Clemmensen, L. K. H. (Intern), Ersbøll, B. K. (Intern)
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BFI (2018): BFI-level 1
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.46 SJR 0.806 SNIP 1.381
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.679 SNIP 1.651 CiteScore 2.23
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.498 SNIP 1.995 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.451 SNIP 1.836 CiteScore 1.94
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.44 SNIP 1.429 CiteScore 1.59
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.581 SNIP 1.991 CiteScore 1.85
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.678 SNIP 1.759
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Improved resolution and reliability in dynamic PET using Bayesian regularization of MRTM2

This paper presents a mathematical model that regularizes dynamic PET data by using a Bayesian framework. We base the model on the well-known two-parameter multilinear reference tissue method MRTM2 and regularize on the assumption that spatially close regions have similar parameters. The developed model is compared to the conventional approach of improving the low signal-to-noise ratio of PET data, i.e., spatial filtering of each time frame independently by a Gaussian kernel. We show that the model handles high levels of noise better than the conventional approach, while at the same time retaining a higher resolution. In addition, it results in a higher reliability between scans on individual subject data, measured by intraclass correlation for absolute agreement.

Improved Change Detection in Forest Areas Based on Stereo Panchromatic Imagery Using Kernel MNF

The goal of this paper is to develop an efficient method for forest change detection using multitemporal stereo panchromatic imagery. Due to the lack of spectral information, it is difficult to extract reliable features for forest change monitoring. Moreover, the forest changes often occur together with other unrelated phenomena, e.g., seasonal changes of land covers such as grass and crops. Therefore, we propose an approach that exploits kernel Minimum Noise Fraction (kMNF) to transform simple change features into high-dimensional feature space. Digital surface models (DSMs) generated from stereo imagery are used to provide information on height difference, which is additionally used to separate forest changes from other land-cover changes. With very few training samples, a change mask is generated with iterated canonical discriminant analysis (ICDA). Two examples are presented to illustrate the approach and demonstrate its efficiency. It is shown that with the same amount of training samples, the proposed method can obtain more accurate
change masks compared with algorithms based on k-means, one-class support vector machine, and random forests.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, German Aerospace Center
Authors: Tian, J. (Ekstern), Nielsen, A. A. (Intern), Reinartz, P. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.29 SJR 2.461 SNIP 3.102
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.559 SNIP 3.241 CiteScore 4.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.486 SNIP 3.582 CiteScore 4.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.467 SNIP 3.355 CiteScore 4.22
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.382 SNIP 3.806 CiteScore 4.26
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.29 SNIP 3.049 CiteScore 3.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.082 SNIP 2.893
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.563 SNIP 3.064
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.38 SNIP 3.141
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.476 SNIP 3.858
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.188 SNIP 2.986
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.032 SNIP 3.156
Influence analysis of Arctic tide gauges using leverages

Reconstructions of historical sea level in the Arctic Ocean are fraught with difficulties related to lack of data, uneven distribution of tide gauges and seasonal ice cover. Considering the period from 1950 to the present, we attempt to identify conspicuous tide gauges in an automated way, using the statistical leverage of each individual gauge. This may be of help in determining appropriate procedures for data preprocessing, of particular importance for the Arctic area as the GIA is hard to constrain and many gauges are located on rivers. We use a model based on empirical orthogonal functions from a calibration period, in this preliminary case Drakkar ocean model data, which are forced using historical tide gauge data from the PSMSL database. The resulting leverage for each tide gauge may indicate that it represents a distinct mode of variability, or that its time series is perturbed in a way inappropriate for the reconstruction so that it should be removed from the reconstruction model altogether. Therefore, the characteristics of the high-leverage gauges are examined in detail.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Applied Mathematics and Computer Science , Image Analysis & Computer Graphics
Authors: Svendsen, P. L. (Intern), Andersen, O. B. (Intern), Nielsen, A. A. (Intern)
Number of pages: 1
Publication date: 2014
Main Research Area: Technical/natural sciences

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Journal: Geophysical Research Abstracts
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Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
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Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
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Influence analysis of Arctic tide gauges using leverages

Reconstructions of historical sea level in the Arctic Ocean are fraught with difficulties related to lack of data, uneven distribution of tide gauges and seasonal ice cover. Considering the period from 1950 to the present, we attempt to identify conspicuous tide gauges in an automated way, using the statistical leverage of each individual gauge. This may be of help in determining appropriate procedures for data preprocessing, of particular importance for the Arctic area as the GIA is hard to constrain and many gauges are located on rivers. We use a model based on empirical orthogonal functions from a calibration period, in this preliminary case Drakkar ocean model data, which are forced using historical tide gauge data from the PSMSL database. The resulting leverage for each tide gauge may indicate that it represents a distinct mode of variability, or that its time series is perturbed in a way inappropriate for the reconstruction so that it should be removed from the reconstruction model altogether. Therefore, the characteristics of the high-leverage gauges are examined in detail.

Interactive Shape Modeling using a Skeleton-Mesh Co-Representation

We introduce the Polar-Annular Mesh representation (PAM). A PAM is a mesh-skeleton co-representation designed for the modeling of 3D organic, articulated shapes. A PAM represents a manifold mesh as a partition of polar (triangle fans) and annular (rings of quads) regions. The skeletal topology of a shape is uniquely embedded in the mesh connectivity of a PAM, enabling both surface and skeletal modeling operations, interchangeably and directly on the mesh itself. We develop an algorithm to convert arbitrary triangle meshes into PAMs as well as techniques to simplify PAMs and a method to convert a PAM to a quad-only mesh. We further present a PAM-based multi-touch sculpting application in order to demonstrate its utility as a shape representation for the interactive modeling of organic, articulated figures as well as for editing and posing of pre-existing models.
Interpretation of appearance: the effect of facial features on first impressions and personality.
Appearance is known to influence social interactions, which in turn could potentially influence personality development. In this study we focus on discovering the relationship between self-reported personality traits, first impressions and facial characteristics. The results reveal that several personality traits can be read above chance from a face, and that facial features influence first impressions. Despite the former, our prediction model fails to reliably infer personality traits from either facial features or first impressions. First impressions, however, could be inferred more reliably from facial features.

We have generated artificial, extreme faces visualising the characteristics having an effect on first impressions for several traits. Conclusively, we find a relationship between first impressions, some personality traits and facial features and
consolidate that people on average assess a given face in a highly similar manner.

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Large Scale Multi-view Stereopsis Evaluation

The seminal multiple view stereo benchmark evaluations from Middlebury and by Strecha et al. have played a major role in propelling the development of multi-view stereopsis methodology. Although seminal, these benchmark datasets are limited in scope with few reference scenes. Here, we try to take these works a step further by proposing a new multi-view stereo dataset, which is an order of magnitude larger in number of scenes and with a significant increase in diversity. Specifically, we propose a dataset containing 80 scenes of large variability. Each scene consists of 49 or 64 accurate camera positions and reference structured light scans, all acquired by a 6-axis industrial robot. To apply this dataset we propose an extension of the evaluation protocol from the Middlebury evaluation, reflecting the more complex geometry of some of our scenes. The proposed dataset is used to evaluate the state of the art multiview stereo algorithms of Tola et al., Campbell et al. and Furukawa et al. Hereby we demonstrate the usability of the dataset as well as gain insight into the workings and challenges of multi-view stereopsis. Through these experiments we empirically validate some of the central hypotheses of multi-view stereopsis, as well as determining and reaffirming some of the central challenges.

Markerless motion capture can provide reliable 3D gait kinematics in the sagittal and frontal plane

Estimating 3D joint rotations in the lower extremities accurately and reliably remains unresolved in markerless motion capture, despite extensive studies in the past decades. The main problems have been ascribed to the limited accuracy of the 3D reconstructions. Accordingly, the purpose of the present study was to develop a new approach based on highly detailed 3D reconstructions in combination with a translational and rotational unconstrained articulated model. The highly detailed 3D reconstructions were synthesized from an eight camera setup using a stereo vision approach. The subject specific articulated model was generated with three rotational and three translational degrees of freedom for each limb segment and without any constraints to the range of motion. This approach was tested on 3D gait analysis and compared to a marker based method. The experiment included ten healthy subjects in whom hip, knee and ankle joint were analysed. Flexion/extension angles as well as hip abduction/adduction closely resembled those obtained from the marker based system. However, the internal/external rotations, knee abduction/adduction and ankle inversion/eversion were less reliable.
Model-Based Motion Tracking of Infants

Even though motion tracking is a widely used technique to analyze and measure human movements, only a few studies focus on motion tracking of infants. In recent years, a number of studies have emerged focusing on analyzing the motion pattern of infants, using computer vision. Most of these studies are based on 2D images, but few are based on 3D information. In this paper, we present a model-based approach for tracking infants in 3D. The study extends a novel study on graph-based motion tracking of infants and we show that the extension improves the tracking results. A 3D model is constructed that resembles the body surface of an infant, where the model is based on simple geometric shapes and a hierarchical skeleton model.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University of Copenhagen
Authors: Olsen, M. D. (Intern), Herskind, A. (Ekstern), Nielsen, J. B. (Ekstern), Paulsen, R. R. (Intern)
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Multiphase Image Segmentation Using the Deformable Simplicial Complex Method

The deformable simplicial complex method is a generic method for tracking deformable interfaces. It provides explicit interface representation, topological adaptivity, and multiphase support. As such, the deformable simplicial complex method can readily be used for representing active contours in image segmentation based on deformable models. We show the benefits of using the deformable simplicial complex method for image segmentation by segmenting an image into a known number of segments characterized by distinct mean pixel intensities.

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Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Image Analysis & Computer Graphics
Authors: Dahl, V. A. (Intern), Christiansen, A. N. (Intern), Bærentzen, J. A. (Intern)
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**N3 Bias Field Correction Explained as a Bayesian Modeling Method**

Although N3 is perhaps the most widely used method for MRI bias field correction, its underlying mechanism is in fact not well understood. Specifically, the method relies on a relatively heuristic recipe of alternating iterative steps that does not optimize any particular objective function. In this paper we explain the successful bias field correction properties of N3 by showing that it implicitly uses the same generative models and computational strategies as expectation maximization (EM) based bias field correction methods. We demonstrate experimentally that purely EM-based methods are capable of producing bias field correction results comparable to those of N3 in less computation time.

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**Novel X-ray phase-contrast tomography method for quantitative studies of heat induced structural changes in meat**

The objective of this study was to evaluate the use of X-ray phase-contrast tomography combined with 3D image segmentation to investigate the heat induced structural changes in meat. The measurements were performed at the Swiss synchrotron radiation light source using a grating interferometric setup. The non-destructive method allowed the same sample to be measured before and after cooking. Heat denaturation resulted in a 36% decrease in the volume of the muscle fibers, while solubilization of the connective tissues increased the volume from 8.4% to 24.9%. The cooking loss was quantified and separated into a water phase and a gel phase formed by the sarcoplasmic proteins in the exudate. The results show that X-ray phase contrast tomography offers unique possibilities in studies both the meat structure and the different meat component such as water, fat, connective tissue and myofibrils in a qualitative and quantitative manner without prior sample preparation as isolation of single muscle components, calibration or histology.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, University of Copenhagen
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On the Benefits of Stereo Graphics in Virtual Obstacle Avoidance Tasks

In virtual reality, stereo graphics is a very common way of increasing the level of perceptual realism in the visual part of the experience. However, stereo graphics comes at cost, both in technical terms and from a user perspective. In this paper, we present the preliminary results of an experiment to see if stereo makes any quantifiable, statistically significant difference in the ability to avoid collisions with virtual obstacles while navigating a 3-D space under constant acceleration. Our results indicate that for this particular application scenario, stereo does provide a significant benefit in terms of the amount of time that participants were able to avoid obstacles.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Aalborg University
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Patient Specific Simulation for Planning of Cochlear Implantation Surgery

Cochlear implantation is a surgical procedure that can restore the hearing capabilities to patients with severe or complete functional loss. However, the level of restoration varies highly between subjects and depends on patient-specific factors. This paper presents a software application for planning cochlear implantation procedures that includes patient-specific anatomy estimation using high resolution models, implant optimization for patient-specific implant selection, simulation of mechanical and electrical properties of the implant as well as clinical reporting.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Computer Vision Center, MED-EL GMBH, University of Bern, Technical University of Denmark, Alma IT Systems, Universitat Pompeu Fabra, Catalan Institution for Research and Advanced Studies
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Patient-Specific Simulation of Implant Placement and Function for Cochlear Implantation Surgery Planning

We present a framework for patient specific electrical stimulation of the cochlea, that allows to perform in-silico analysis of implant placement and function before surgery. A Statistical Shape Model (SSM) is created from high-resolution human μCT data to capture important anatomical details. A Finite Element Model (FEM) is built and adapted to the patient using the results of the SSM. Electrical simulations based on Maxwell’s equations for the electromagnetic field are performed on this personalized model. The model includes implanted electrodes and nerve fibers. We present the results for the bipolar stimulation protocol and predict the voltage spread and the locations of nerve excitation.

Pattern recognition approach to quantify the atomic structure of graphene

We report a pattern recognition approach to detect the atomic structure in high-resolution transmission electron microscopy images of graphene. The approach provides quantitative information such as carbon-carbon bond lengths and bond length variations on a global and local scale alike. © 2014 Elsevier Ltd. All rights reserved.
Photon Differential Splatting for Rendering Caustics

We present a photon splatting technique which reduces noise and blur in the rendering of caustics. Blurring of illumination edges is an inherent problem in photon splatting, as each photon is unaware of its neighbours when being splatted. This means that the splat size is usually based on heuristics rather than knowledge of the local flux density. We use photon differentials to determine the size and shape of the splats such that we achieve adaptive anisotropic flux density estimation in photon splatting. As compared to previous work that uses photon differentials, we present the first method where no photons or beams or differentials need to be stored in a map. We also present improvements in the theory of photon differentials, which give more accurate results and a faster implementation. Our technique has good potential for GPU acceleration, and we limit the number of parameters requiring user adjustment to an overall smoothing parameter and the number of photons to be traced.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, 3Shape, University of Copenhagen
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Potential of multispectral imaging technology for rapid and non-destructive determination of the microbiological quality of beef fillets during aerobic storage

The performance of a multispectral imaging system has been evaluated in monitoring aerobically packaged beef filet spoilage at different storage temperatures (0, 4, 8, 12, and 16°C). Spectral data in the visible and short wave near infrared area (405–970nm) were collected from the surface of meat samples and correlated with microbiological data (log counts), for total viable counts (TVCs), Pseudomonas spp., and Brochothrix thermosphacta. Qualitative analysis (PLS-DA) was employed for the discrimination of meat samples in three microbiological quality classes based on the values of total viable counts, namely Class 1 (TVC7.0log10CFU/g). Furthermore, PLS regression models were developed to provide quantitative estimations of microbial counts during meat storage. In both cases model validation was implemented with independent experiments at intermediate storage temperatures (2 and 10°C) using different batches of meat. Results demonstrated good performance in classifying meat samples with overall correct classification rate for the three quality classes ranging from 91.8% to 80.0% for model calibration and validation, respectively. For quantitative estimation, the calculated regression coefficients between observed and estimated counts ranged within 0.90–0.93 and 0.78–0.86 for model development and validation, respectively, depending on the microorganism. Moreover, the calculated average deviation between observations and estimations was 11.6%, 13.6%, and 16.7% for Pseudomonas spp., B. thermosphacta, and TVC, respectively. The results indicated that multispectral vision technology has significant potential as a rapid and non-destructive technique in assessing the microbiological quality of beef fillets.
Quantification Tools for Analyzing Tomograms of Energy Materials

The structure of materials used in the energy sector, such as catalysts, CO2 and hydrogen storage materials or fiber composites is intrinsically heterogeneous. The efficiency and lifetime of devices depends critically on the details of the materials’ 3D microstructure and the relation between such structures. Recently developed X-ray imaging techniques provide a resolution that allows for seeing inside a device without destroying it.

There are a number of analysis tasks that need to be carried out in order to harvest the benefits from state of the art X-ray imaging techniques. This includes image segmentation of the reconstructed volumes. By segmenting structures we are able to measure size and shape and quantify important structures. Examples include pores and interface distributions in a catalyst, or glass fiber size, shape and length distributions in a wind turbine blade.

We have a method that, based on a manually annotated training image, can learn local image patterns. These patterns are used to separate image structures that do not deviate in average image intensity but only in the local image structure. Using this method we can precisely solve segmentation problems, e.g. separating detailed structures like fibers, which would not be possible with traditional segmentation methods. The segmentation and analysis tools we develop in this project will be central in solving problems for predicting flow or damage in energy materials.
Rapid Generation of Personalized HRTFs
Numerical simulations offer a viable alternative to measurements for generating personalized head-related transfer functions (HRTFs). The fast multipole boundary element method (FM-BEM) is a popular method for simulating the HRTFs since it requires a surface mesh of the head (and torso) only. The FM-BEM simulation of the HRTF at a single frequency can be computed in a few minutes. Utilizing cloud computing, the entire audible frequency range can be simulated in less than an hour. A bottleneck in the fast acquisition of the personalized HRTFs has been the complexity of generating good quality head models for the simulation. We compare three photography based geometry acquisition methods, ranging from a system of 52 cameras to a method using a single mobile phone camera only.

Secondary Progressive and Relapsing Remitting Multiple Sclerosis Leads to Motor-Related Decreased Anatomical Connectivity
Multiple sclerosis (MS) damages central white matter pathways which has considerable impact on disease-related disability. To identify disease-related alterations in anatomical connectivity, 34 patients (19 with relapsing remitting MS (RR-MS), 15 with secondary progressive MS (SP-MS) and 20 healthy subjects underwent diffusion magnetic resonance imaging (dMRI) of the brain. Based on the dMRI, anatomical connectivity mapping (ACM) yielded a voxel-based metric reflecting the connectivity shared between each individual voxel and all other brain voxels. To avoid biases caused by inter-individual brain-shape differences, they were estimated in a spatially normalized space. Voxel-based statistical analyses using ACM were compared with analyses based on the localized microstructural indices of fractional anisotropy (FA). In both RR-MS and SP-MS patients, considerable portions of the motor-related white matter revealed decreases in ACM and FA when compared with healthy subjects. Patients with SP-MS exhibited reduced ACM values relative to RR-MS in the motor-related tracts, whereas there were no consistent decreases in FA between SP-MS and RR-MS patients. Regional ACM statistics exhibited moderate correlation with clinical disability as reflected by the expanded disability status scale (EDSS). The correlation between these statistics and EDSS was either similar to or stronger than the correlation between FA statistics and the EDSS. Together, the results reveal an improved relationship between ACM, the clinical phenotype, and impairment. This highlights the potential of the ACM connectivity indices to be used as a marker which can identify disease related-alterations due to MS which may not be seen using localized microstructural indices.
Segmentation of Connective Tissue in Meat from Microtomography Using a Grating Interferometer

It has been demonstrated that phase contrast imaging provides superior contrast of soft tissues in biological material over typical absorption tomography [1-2]. In meat science, this imaging modality can provide valuable information of the effects of heat treatment on muscle tissue. Although microtomography provides high resolution, the thin structures of the connective tissues are difficult to segment. This is mainly due to partial object voxels, image noise and artifacts. The segmentation of connective tissue is important for quantitative analysis purposes. Factors such as the surface area, relative volume and the statistics of the electron density of the connective tissue could prove useful for understanding the structural changes occurring in the meat sample due to heat treatment.
In this study a two step segmentation algorithm was implemented in order to segment connective tissue from phase contrast microtomograms obtained by a grating interferometer. This segmentation has previously been demonstrated for the segmentation of the optic nerve head from microscopic images of stained slices [3]. The first step is to model the data as a mixture of Gaussians using an expectation-maximization (EM) algorithm [4]. This iterative process finds the maximum likelihood of parameters where the model depends on unobserved latent variables. The spatial information of the data is next incorporated into the segmentation process by modeling the data as a Markov random field (MRF) [5]. It models the a priori probability of neighborhood dependencies, and the field can either be isotropic or anisotropic. For the segmentation of connective tissue, the local information of the structure orientation and coherence is extracted to steer the smoothing (anisotropy) of the final segmentation.

The results show that the segmentation provides a superior classification of connective tissue over conventional threshold segmentation. Additionally modeling the data as a mixture of Gaussians made it possible to segment the connective tissue into two separate classes. The segmentation results provide the means for further analysis of the structural changes in the meat due to heat treatment.

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**Segmentation Toolbox for Tomographic Image Data**

Motivation: Image acquisition has vastly improved over the past years, introducing techniques such as X-ray computed tomography (CT). CT images provide the means to probe a sample non-invasively to investigate its inner structure. Given the wide usage of this technique and massive data amounts, techniques to automatically analyze such data becomes ever more important. Most segmentation methods for large datasets, such as CT images, deal with simple thresholding techniques, where intensity values cut offs are predetermined and hard coded. For data where the intensity difference is not sufficient, and partial volume voxels occur frequently, thresholding methods do not suffice and more advanced methods are required.

Contribution: To meet these requirements a toolbox has been developed, combining well known methods within the image analysis field. The toolbox includes cluster-based methods to automatically determine parameters of the different classes present in the data, and edge weighted smoothing of the final segmentation based on Markov Random Fields (MRF). The toolbox is developed for Matlab users and requires only minimal background knowledge of Matlab.

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SLStudio: Open-source framework for real-time structured light

An open-source framework for real-time structured light is presented. It is called “SLStudio”, and enables real-time capture of metric depth images. The framework is modular, and extensible to support new algorithms for scene encoding/decoding, triangulation, and acquisition hardware. It is the aim that this software makes real-time 3D scene capture more widely accessible and serves as a foundation for new structured light scanners operating in real-time, e.g. 20 depth images per second and more. The use cases for such scanners are plentiful, however due to the computational constraints, all public implementations so far are limited to offline processing. With “SLStudio”, we are making a platform available which enables researchers from many different fields to build application specific real time 3D scanners. The software is hosted at http://compute.dtu.dk/~jakw/slstudio.

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- **Organisations:** Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
- **Authors:** Wilm, J. (Intern), Olesen, O. V. (Intern), Larsen, R. (Intern)
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- **Computing and Processing, Robotics and Control Systems, Signal Processing and Analysis, Calibration, Cameras, computer vision, Decoding, Encoding, Image and video processing, Image processing tools, Images acquisition systems and information extraction, Real-time systems, Software, Three-dimensional displays**
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- **Source-ID:** 273908871
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Status for NEXIM New X-ray Imaging Modalities for safe and high quality food
The main objectives of the NEXIM project are to develop the novel X-ray grating interferometry technique (Weitkamp et al. 2005; Pfieffer et al. 2008) specifically towards food application and to identify the areas within the Danish food industry with the highest technological and commercial impact. The main focuses are determined to be threefold:

1) Improving the detectability of low density foreign bodies incidentally present in food products.
2) Development of new modalities for assessment of quality traits in food production, for instance connective tissue and fatty acid composition.
3) Develop a proof-of-principle of a conveyor belt solution that can form the basis for real product development.

In the past year the NEXIM project has focused on these three objectives, studying the applicability of GBI to meat quality assessment and foreign object detection. Some efforts have been put to developing laboratory-based setups further towards an in-line scanning system. Additionally, close co-operation with industrial partners has further emphasized the need for new techniques for quality control, product development and foreign object detection.

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Structure Identification in High-Resolution Transmission Electron Microscopic Images: An Example on Graphene
A connection between microscopic structure and macroscopic properties is expected for almost all material systems. High-resolution transmission electron microscopy is a technique offering insight into the atomic structure, but the analysis of large image series can be time consuming. The present work describes a method to automatically estimate the atomic structure in two-dimensional materials. As an example graphene is chosen, in which the positions of the carbon atoms are reconstructed. Lattice parameters are extracted in the frequency domain and an initial atom positioning is estimated. Next, a plausible neighborhood structure is estimated. Finally, atom positions are adjusted by simulation of a Markov random field model, integrating image evidence and the strong geometric prior. A pristine sample with high regularity and a sample with an induced hole are analyzed. False discovery rate-controlled large-scale simultaneous hypothesis testing is used as a statistical framework for interpretation of results. The first sample yields, as expected, a homogeneous distribution of carbon–carbon (C–C) bond lengths. The second sample exhibits regions of shorter C–C bond lengths with a preferred orientation, suggesting either strain in the structure or a buckling of the graphene sheet. The precision of the method is demonstrated on simulated model structures and by its application to multiple exposures of the two graphene samples.

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Organisations: Department of Applied Mathematics and Computer Science, Center for Electron Nanoscopy, Center for Nanostructured Graphene, Image Analysis & Computer Graphics
Authors: Vestergaard, J. S. (Intern), Kling, J. (Intern), Dahl, A. B. (Intern), Hansen, T. W. (Intern), Wagner, J. B. (Intern), Larsen, R. (Intern)
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Surface Detection using Round Cut
We propose an iterative method for detecting closed surfaces in a volumetric data, where an optimal search is performed in a graph built upon a triangular mesh. Our approach is based on previous techniques for detecting an optimal terrain-like or tubular surface employing a regular grid. Unlike similar adaptations for triangle meshes, our method is capable of capturing complex geometries by iteratively refining the surface, where we obtain a high level of robustness by applying explicit mesh processing to intermediate results. Our method uses on-surface data support, but it also exploits data information about the region inside and outside the surface. This provides additional robustness to the algorithm. We demonstrate the capabilities of the approach by detecting surfaces of CT scanned objects.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Image Analysis & Computer Graphics
Authors: Dahl, V. A. (Intern), Dahl, A. B. (Intern), Larsen, R. (Intern)
Number of pages: 8
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The effect of gender on eye colour variation in European populations and an evaluation of the IrisPlex prediction model
In two recent studies of Spanish individuals [1,2], gender was suggested as a factor that contributes to human eye colour variation. However, gender did not improve the predictive accuracy on blue, intermediate and brown eye colours when gender was included in the IrisPlex model [3]. In this study, we investigate the role of gender as a factor that contributes to eye colour variation and suggest that the gender effect on eye colour is population specific. A total of 230 Italian individuals were typed for the six IrisPlex SNPs (rs12913832, rs1800407, rs12896399, rs1393350, rs16891982 and rs12203592). A quantitative eye colour score (Pixel Index of the Eye: PIE-score) was calculated based on digital eye images using the custom made DIAT software. The results were compared with those of Danish and Swedish population samples. As expected, we found HERC2 rs12913832 as the main predictor of human eye colour independently of ancestry. Furthermore, we found gender to be significantly associated with quantitative eye colour measurements in the Italian population sample. We found that the association was statistically significant only among Italian individuals typed as heterozygote GA for HERC2 rs12913832. Interestingly, we did not observe the same association in the Danish and Swedish population. This indicated that the gender effect on eye colour is population specific. We estimated the effect of gender on quantitative eye colour in the Italian population sample to be 4.9%. Among gender and the IrisPlex SNPs, gender ranked as the second most important predictor of human eye colour variation in Italians after HERC2 rs12913832. We, furthermore, tested the five lower ranked IrisPlex predictors, and evaluated all possible 36 (729) genotype combinations of the IrisPlex assay and their corresponding predictive values using the IrisPlex prediction model [4]. The results suggested that maximum three (rs12913832, rs1800407, rs16891982) of the six IrisPlex SNPs are useful in practical forensic genetic casework.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Aalborg University, University of Copenhagen
Authors: Pietroni, C. (Ekstern), Andersen, J. D. (Ekstern), Johansen, P. (Ekstern), Andersen, M. M. (Ekstern), Harder, S. (Intern), Paulsen, R. R. (Intern), Børsting, C. (Ekstern), Morling, N. (Ekstern)
Topography optimization using an explicit interface representation

We introduce the Deformable Simplicial Complex method to topology optimization as a way to represent the interface explicitly yet being able to handle topology changes. Topology changes are handled by a series of mesh operations, which also ensures a well-formed mesh. The same mesh is therefore used for both finite element calculations and shape representation. In addition, the approach unifies shape and topology optimization in a complementary optimization strategy. The shape is optimized on the basis of the gradient-based optimization algorithm MMA whereas holes are introduced using topological derivatives. The presented method is tested on two standard minimum compliance problems which demonstrates that it is both simple to apply, robust and efficient.
Validation of a new technique to estimate regional cerebral blood flow in piglets using fluorescent microspheres

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Authors: Henning, W. (Ekstern), Andersen, J. (Ekstern), Christensen, A. N. (Intern), Greisen, G. (Ekstern), Liselotte, H. (Ekstern), Law, I. (Ekstern)
Pages: 1
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.253 SNIP 1.933 CiteScore 4.66
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.715 SNIP 2.036 CiteScore 5
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.494 SNIP 2.118 CiteScore 5.08
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.549 SNIP 2.29
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.935 SNIP 2.171
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.213 SNIP 2.111
Scopus rating (2007): SJR 2.576 SNIP 2.323
Scopus rating (2006): SJR 2.153 SNIP 1.819
Vision-based method for tracking meat cuts in slaughterhouses

Meat traceability is important for linking process and quality parameters from the individual meat cuts back to the production data from the farmer that produced the animal. Current tracking systems rely on physical tagging, which is too intrusive for individual meat cuts in a slaughterhouse environment. In this article, we demonstrate a computer vision system for recognizing meat cuts at different points along a slaughterhouse production line. More specifically, we show that 211 pig loins can be identified correctly between two photo sessions. The pig loins undergo various perturbation scenarios (hanging, rough treatment and incorrect trimming) and our method is able to handle these perturbations gracefully. This study shows that the suggested vision-based approach to tracking is a promising alternative to the more intrusive methods currently available.
3D gender recognition using cognitive modeling
We use 3D scans of human faces and cognitive modeling to estimate the “gender strength”. The “gender strength” is a continuous class variable of the gender, superseding the traditional binary class labeling. To visualize some of the visual trends humans use when performing gender classification, we use linear regression. In addition, we use the gender strength to construct a smaller but refined training set, by identifying and removing ill-defined training examples. We use this refined training set to improve the performance of known classification algorithms. Results are presented using a 5-fold cross-validation scheme and also reproduced using an unseen data set.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Cognitive Systems, Copenhagen University Hospital
Authors: Fagertun, J. (Intern), Andersen, T. (Intern), Hansen, T. (Ekstern), Paulsen, R. R. (Intern)
Number of pages: 4
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Publisher: IEEE
ISBN (Print): 978-1-4673-4987-1
Main Research Area: Technical/natural sciences
3D Surface Realignment Tracking for Medical Imaging: A Phantom Study with PET Motion Correction

We present a complete system for motion correction in high resolution brain positron emission tomography (PET) imaging. The system is based on a compact structured light scanner mounted above the patient tunnel of the Siemens High Resolution Research Tomograph (HRRT) PET brain scanner. The structured light system is equipped with a near infrared diode and uses phase-shift interferometry (PSI) to compute 3D point clouds of the forehead of the patient. These 3D point clouds are progressively aligned to a reference surface, thereby giving the head pose changes. The estimated pose changes are used to reposition a sequence of reconstructed PET frames. To align the structured light system with the PET coordinate system, a novel registration algorithm based on the PET transmission scan and an initial surface has been developed. The performance of the complete setup has been evaluated using a custom-made phantom, based on a plastic mannequin head equipped with two positron-emitting line sources. Two experiments were performed. The first simulates rapid and short head movements, while the second simulates slow and continuous movements. In both cases, the system was able to produce PET scans with focused PET reconstructions. The system is nearly ready for clinical testing.

A Comparison of Meat Colour Measurements From a Colorimeter and Multispectral Images

We compare meat colour measurements from a colorimeter and multispectral images. The measurements were performed on pork and beef samples. The colorimeter measurements were taken at 45°/0° geometry, while the multispectral images were acquired using a camera with a multispectral filter set. Two experiments were performed. The first experiment was performed on pork samples, while the second experiment was performed on beef samples. The results show that the colorimeter measurements were more affected by the light source than the multispectral images. The multispectral images were more consistent across different samples and light sources.
Adapting Parcellation Schemes to Study Fetal Brain Connectivity in Serial Imaging Studies

A crucial step in studying brain connectivity is the definition of the Regions Of Interest (ROI's) which are considered as nodes of a network graph. These ROI's identified in structural imaging reflect consistent functional regions in the anatomies being compared. However in serial studies of the developing fetal brain such functional and associated structural markers are not consistently present over time. In this study we adapt two non-atlas based parcellation schemes to study the development of connectivity networks of a fetal monkey brain using Diffusion Weighted Imaging techniques. Results demonstrate that the fetal brain network exhibits small-world characteristics and a pattern of increased cluster coefficients and decreased global efficiency. These findings may provide a route to creating a new biomarker for healthy fetal brain development.

Adaptive mesh generation for image registration and segmentation

This paper deals with the problem of generating quality tetrahedral meshes for image registration. From an initial coarse mesh the approach matches the mesh to the image volume by combining red-green subdivision and mesh evolution through mesh-to-image matching regularized with a mesh quality measure. The method was tested on a T1 weighted MR volume of an adult brain and showed a 66% reduction in the number of mesh vertices compared to a red-subdivision strategy. The deformation capability of the mesh was tested by registration to five additional T1-weighted MR volumes.
**A kernel version of multivariate alteration detection**

Based on the established methods kernel canonical correlation analysis and multivariate alteration detection we introduce a kernel version of multivariate alteration detection. A case study with SPOT HRV data shows that the kMAD variates focus on extreme change observations.

**General information**

State: Published
Organisations: National Space Institute, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Nielsen, A. A. (Intern), Vestergaard, J. S. (Intern)
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Source: dtu
Source-ID: u::9962
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

**Analysis of sea-level reconstruction techniques for the Arctic Ocean**

Sea-level reconstructions spanning several decades have been examined in numerous studies for most of the world’s ocean areas, where satellite missions such as TOPEX/Poseidon and Jason-1 and -2 have provided much-improved knowledge of variability and long-term changes in sea level. However, these dedicated oceanographic missions are limited in coverage to between ±66° latitude, and satellite altimeter data at higher latitudes is of a substantially worse quality. Following the approach of Church et al. (2004), we apply a model based on empirical orthogonal functions (EOFs) to the Arctic Ocean, constrained by tide gauge records. A major challenge for this area is the sparsity of both satellite and tide gauge data beyond what can be covered with interpolation, necessitating a time-variable model and consideration to data preprocessing, including selection of appropriate tide gauges. In order to have a reasonable amount of tide gauge data available, we focus on a reconstruction timespan of the last five decades, and the implementation of the model is validated by applying it to global sea-level data. We examine the influence of the individual tide gauges on the resulting solution and the ability of the model to reconstruct known data, in addition to the effects of regularization techniques and the relationship with climatological indices such as the Arctic Oscillation (AO). EOFs are obtained in a preliminary analysis from existing ocean models such as DRAKKAR, and from satellite data (from the ERS-1 and -2 and Envisat missions). In addition to EOFs, we also implement an alternative decomposition technique known as minimum/maximum autocorrelation factors (MAF), based on the temporal or spatial autocorrelation within the calibration period, rather than explained variance.

**General information**

State: Published
Organisations: National Space Institute, Geodesy, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Svendsen, P. L. (Intern), Andersen, O. B. (Intern), Nielsen, A. A. (Intern)
Number of pages: 1
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Main Research Area: Technical/natural sciences
Electronic versions: aguposter.pdf
Source: PublicationPreSubmission
Source-ID: 96385004
Publication: Research - peer-review › Poster – Annual report year: 2013

**Analysis of the Indented Cylinder by the use of Computer Vision**

The research summarised in this PhD thesis took advantage of methods from computer vision to experimentally analyse the sorting/separation ability of a specific type of seed sorting device – known as “indented cylinder”. The indented cylinder basically separates incoming seeds into two sub-groups:
(1) "long" seeds and (2) "short" seeds (known as length-separation). The motion of seeds being physically manipulated inside an active indented cylinder was analysed using various computer vision methods. The data from such analyses were used to create an overview of the machine’s ability to separate certain species of seed from each other. Seeds are processed in order to achieve a high-quality end product: a batch of a single species of crop seed. Naturally, farmers need processed clean crop seeds that are free from non-seed impurities, weed seeds, and non-viable or dead crop seeds. Since the processing is based on physical manipulation of the seeds themselves, their individual shape and size becomes very relevant. The problem of modelling such physical parameters for various species of seed, grown under various environmental circumstances, is a very complex one. The general problem of modelling and controlling seed processing equipment can be expected to be complex. Due to the involvement of seeds, the problem will naturally inherit all their biological complexities. In addition to this, because of the very large number of individual seeds, the problem also involves a granular media and thus inherits all the complexities related to that as well.

The project arrived at a number of results of high scientific and practical value to the area of applied computer vision and seed processing and agricultural technology in general. The results and methodologies were summarised in one conference paper and two journal papers. These three papers, referred to as Paper I, Paper II, and Paper III can be found in Appendix A, B, and C, respectively. These three papers represent the very first examples of published/submitted work that thoroughly analyse and verify the separation ability of the indented cylinder by the use of computer vision (or image analysis). Moreover, the imagery data sets, generated as a result of actual recordings of sorting experiments using the indented cylinder, are novel by their high dimensionality and size. Paper II in Appendix B makes one of these data sets available online as a cite-aware imagery data set. The work summarised in this thesis is very much related to the task of constructing models from observed data. This field is known as empirical model development or more specifically as "system identification". System identification deals specifically with estimating mathematical models from observed dynamic states (time series) of inputs and outputs to and from some physical system under investigation. The contribution of the work is to be found primarily within the problem domain of experimentation for system identification. Computer vision techniques were used to acquire observations of a measure of separation efficiency of the indented cylinder. Such techniques for observation are likely to be very relevant for experimentation in a laboratory for system identification purposes. This work should therefore be seen as an important step towards future research in system identification of the indented cylinder. The technical solutions developed are currently novel and represent an ideal platform for future applied research into empirical model development. Finally, this work should also be considered as an early step toward a paradigm shift where the best parameters for the indented cylinder are not mainly determined by “rule of thumb” and other forms of heuristics, but are instead optimized parameters tied to an actual theory of seed separation in the indented cylinder.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Aarhus University
Authors: Buus, O. T. (Intern), Jørgensen, J. R. (Ekstern), Carstensen, J. M. (Intern)
Number of pages: 169
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An explorative study on pork loin recognition
Bag-of-words (BoW) image description has shown good performance for a large variety of image recognition scenarios. We investigate approaches to alleviating a standard BoW image description pipeline representations for the specific task of recognizing pork loins. Specifically, we extend the BoW description to include depth maps, perform non-rigid image registration to align the images, and apply PCA dimensionality reduction on the BoW descriptors. Our results show that the combination of image registration and PCA yields a more distinctive recognition.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Danish Meat Research Institute, Technical University of Denmark
Authors: Larsen, A. B. L. (Intern), Hviid, M. S. (Forskerdatabase), Larsen, R. (Intern), Dahl, A. L. (Ekstern)
Pages: 49-54
Publication date: 2013

Host publication information
An Improved Optimization Method for the Relevance Voxel Machine

In this paper, we will re-visit the Relevance Voxel Machine (RVoxM), a recently developed sparse Bayesian framework used for predicting biological markers, e.g., presence of disease, from high-dimensional image data, e.g., brain MRI volumes. The proposed improvement, called IRVoxM, mitigates the shortcomings of the greedy optimization scheme of the original RVoxM algorithm by exploiting the form of the marginal likelihood function. In addition, it allows voxels to be added and deleted from the model during the optimization. In our experiments we show that IRVoxM outperforms RVoxM on synthetic data, achieving a better training cost and test root mean square error while yielding sparser models. We further evaluated IRVoxM’s performance on real brain MRI scans from the OASIS data set, and observed the same behavior - IRVoxM retains good prediction performance while yielding much sparser models than RVoxM.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School
Authors: Ganz, M. (Ekstern), Sabuncu, M. R. (Ekstern), Van Leemput, K. (Intern)
Pages: 147-154
Publication date: 2013

Apparatus and method for motion tracking in brain imaging

Disclosed is apparatus and method for motion tracking of a subject in medical brain imaging. The method comprises providing a light projector and a first camera; projecting a first pattern sequence (S1) onto a surface region of the subject with the light projector, wherein the subject is positioned in a scanner borehole of a medical scanner, the first pattern sequence comprising a first primary pattern (P1,1) and/or a first secondary pattern (P1,2); detecting the projected first pattern sequence (S1) with the first camera; determining a second pattern sequence (S2) comprising a second primary pattern (P2,1) based on the detected first pattern sequence (S1); projecting the second pattern sequence (S2) onto a surface region of the subject with the light projector; detecting the projected second pattern sequence (S2) with the first camera; and determining motion tracking parameters based on the detected second pattern sequence (S2).

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Biomedical Engineering
Application of X-ray phase-contrast tomography in quantitative studies of heat induced structural changes in meat

X-ray computed tomography is increasingly used in the studies of food structure. This paper describes the perspectives of use of phase contrast computed tomography in studies of heat induced structural changes in meat. From the data it was possible to obtain reconstructed images of the sample structure for visualization and qualitative studies of the sample structure. Further data segmentation allowed structural changes to be quantified.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis, University of Copenhagen
Authors: Miklos, R. (Ekstern), Nielsen, M. S. (Ekstern), Einarsdottir, H. (Intern), Lametsch, R. (Ekstern)
Number of pages: 4
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A Probabilistic, Non-parametric Framework for Inter-modality Label Fusion

Multi-atlas techniques are commonplace in medical image segmentation due to their high performance and ease of implementation. Locally weighting the contributions from the different atlases in the label fusion process can improve the quality of the segmentation. However, how to define these weights in a principled way in inter-modality scenarios remains an open problem. Here we propose a label fusion scheme that does not require voxel intensity consistency between the atlases and the target image to segment. The method is based on a generative model of image data in which each intensity in the atlases has an associated conditional distribution of corresponding intensities in the target. The segmentation is computed using variational expectation maximization (VEM) in a Bayesian framework. The method was evaluated with a dataset of eight proton density weighted brain MRI scans with nine labeled structures of interest. The results show that the algorithm outperforms majority voting and a recently published inter-modality label fusion algorithm.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Harvard Medical School
Authors: Iglesias, J. E. (Ekstern), Sabuncu, M. R. (Ekstern), Van Leemput, K. (Intern)
Pages: 576-583
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Host publication information
A three dimensional children head database for acoustical research and development

Most computational-acoustic work within spatial hearing relies on head-related transfer functions from databases of measurements taken on adult humans or dummy heads. We aim to provide a set of 3D digital heads including children, from which head-related transfer functions can be computed instead of measured. However, current volumetric scanning techniques do not have sufficient resolution for accurately scanning the external ear, and computed tomography also involves radiation. In this paper we propose a framework for scanning, stitching and meshing complete human heads. The process starts by acquisition of multiple 3D surface scans of the same subject using a high-resolution photogrammetric scanner. Secondly, the scans are semi-automatically aligned and noise and incoherence is removed. This is followed by an iterative process where a volumetric implicit representation of the head is optimized. The process consists of a regularized surface reconstruction step followed by an alignment step. Finally, a surface representation of the entire head is extracted using a triangulation of the zero-level iso-surface of the implicit volume. The process has been used to reconstruct the heads of children aged 10 months to 9 years. The data and the associated reconstruction algorithms will be made publicly available for use in acoustical research and development.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science , Image Analysis & Computer Graphics
Authors: Harder, S. (Intern), Paulsen, R. R. (Intern), Larsen, M. (Ekstern), Laugesen, S. (Ekstern)
Number of pages: 9
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ISI indexed (2012): ISI indexed no
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Original language: English
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A unified framework for cross-modality multi-atlas segmentation of brain MRI

Multi-atlas label fusion is a powerful image segmentation strategy that is becoming increasingly popular in medical imaging. A standard label fusion algorithm relies on independently computed pairwise registrations between individual atlases and the (target) image to be segmented. These registrations are then used to propagate the atlas labels to the target space and fuse them into a single final segmentation. Such label fusion schemes commonly rely on the similarity between intensity values of the atlases and target scan, which is often problematic in medical imaging - in particular, when the atlases and target images are obtained via different sensor types or imaging protocols. In this paper, we present a generative probabilistic model that yields an algorithm for solving the atlas-to-target registrations and label fusion steps simultaneously. The proposed model does not directly rely on the similarity of image intensities. Instead, it exploits the consistency of voxel intensities within the target scan to drive the registration and label fusion, hence the atlases and target image can be of different modalities. Furthermore, the framework models the joint warp of all the atlases, introducing interdependence between the registrations. We use variational expectation maximization and the Demons registration framework in order to efficiently identify the most probable segmentation and registrations. We use two sets of experiments to illustrate the approach, where proton density (PD) MRI atlases are used to segment T1-weighted brain scans and vice versa. Our results clearly demonstrate the accuracy gain due to exploiting within-target intensity consistency and integrating registration into label fusion.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Massachusetts General Hospital
Authors: Eugenio Iglesias, J. (Ekstern), Rory Sabuncu, M. (Ekstern), Van Leemput, K. (Intern)
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Scopus rating (2016): SJR 1.948 SNIP 2.838 CiteScore 5.69
BFI (2015): BFI-level 2
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Scopus rating (2014): SJR 1.505 SNIP 3.277 CiteScore 5.32
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 1.782 SNIP 3.533 CiteScore 5.61
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.52 SNIP 3.023 CiteScore 5.01
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.543 SNIP 3.761 CiteScore 5.7
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 3.05
Automated Image-Based Procedures for Adaptive Radiotherapy

Fractionated radiotherapy for cancer treatment is a field of constant innovation. Developments in dose delivery techniques have made it possible to precisely direct ionizing radiation at complicated targets. In order to further increase tumour control probability (TCP) and decrease normal-tissue complication probability (NTCP), margins used to account for interfraction and intrafraction anatomical changes and motion need to be reduced. This can only be achieved through proper treatment plan adaptations and intrafraction motion management.

This thesis describes methods in support of image-based treatment replanning and real-time intrafraction guidance techniques. The selected contributions detail a number of findings and techniques, in particular:

- For ten head & neck cancer patients, changes in tumour density were well described by linear functions with patient-specific slope and intercept. This is of particular interest for proton therapy as delivered dose to a tissue and calculated dose distributions rely on density. Furthermore, tumour density changes might be indicative of treatment response.
- It is demonstrated how spatially varying elasticity parameters can be employed in image registration to encourage bone rigidity and local tissue volume change only in the gross tumour volume and the lungs. This is highly relevant in adaptive radiotherapy when modelling significant tumour volume changes.
- It is described how cone beam CT reconstruction can be modelled as a deformation of a planning CT scan of the same patient, using a non parametric diffusion based deformation model, opening the door to the use of a number of advanced non-parametric algorithms. An advantage of reconstruction by deformation is that no subsequent image registration is needed in order to obtain the deformation which can be employed for contour propagation in adaptive radiotherapy.
- MRI-radiotherapy devices have the potential to offer near real-time intrafraction imaging without any additional ionising radiation. It is detailed how the use of multiple, orthogonal slices can form the basis for reliable 3D soft tissue tracking.
Automated Structure Detection in HRTEM Images: An Example with Graphene

Graphene, as the forefather of 2D-materials, attracts much attention due to its extraordinary properties like transparency, flexibility and outstanding high conductivity, together with a thickness of only one atom. The properties seem to be dependent on the atomic structure of graphene and therefore characterizations on the atomic level are of interest. High-resolution transmission electron microscopy (HRTEM) is a state-of-the-art method to characterize the atomic structure of materials. Due to the inherently low mass-thickness of graphene, the contrast levels in the recorded images are often challenging to interpret. In order to increase the signal-to-noise ratio of the images two routes can be pursued: 1) the exposure time can be increased; or 2) acquiring series of images and summarize them after alignment. Both methods have the disadvantage of summing images acquired over a certain period of time making it difficult to resolve dynamic processes or unstable structures. Tools that assist to get the maximum of information out of recorded images are therefore greatly appreciated.

In order to get the most accurate results out of the structure detection, we have optimized the imaging conditions used for the FEI Titan ETEM with a monochromator and an objective-lens Cs-corrector. To reduce the knock-on damage of the carbon atoms in the graphene structure, the microscope was operated at 80kV. As this strongly increases the influence of the chromatic aberration of the lenses, the energy spread of the electron gun was reduced. Using the monochromator an energy spread of <0.2eV can be achieved. This gives a resolution better then 1.2Å which allow us to resolve the second order reflection of graphene and to visualize the atomic structure in HRTEM (fig. 1).

These images serve as a basis for the image analysis. Single-layer graphene with its regular honeycomb lattice is a perfect model structure to apply automated structure detection. By utilizing Fourier analysis the initial perfect hexagonal structure can easily be recognized. The recorded hexagonal tessellation reflects the unperturbed structure in the image. The centers of the C-hexagons are displayed as nodes. To segment the image into “pure” and “impure” regions, like areas with residual amorphous contamination or defects e.g. holes, a sliding window approach is used. The magnitude of the Fourier transformation within a window is compared to that of a perfect hexagonal tessellation. Areas where this relation exceeds a threshold are recognized as “impure” and a mask is created. As a result, the hexagonal tessellation overlays only the “pure” graphene structure in the image.

As the real graphene structure is never perfect and undisturbed, at least at a length-scale of several nm, the model structure has to be adjusted to the real structure. At this point, the image quality plays a crucial role. The algorithm assumes that irregularities in the graphene can be explained by a deformation in the xy-plane. To model this, a set of tensor B-splines is employed, which is deformed by matching model grid points with the C-hexagon centers. Dependent on the Cs and defocus-settings during microscopy these centers appear either dark or bright. One ends up with a deformed hexagonal tessellation, which can easily be transformed into a honeycomb lattice with the C-atom positions included. As the microstructure is now available in the model, information like the C-C distance can be visualized as shown in fig. 2.

Applying this method, the perfect graphene structure in recorded HRTEM-images can be determined fast and accurate over a wide length scale, and at the same time lattice deformations can be visualized. The method will be refined to facilitate the detection of larger defects like holes and the determination of the edge terminations.

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Microscopy and Microanalysis 2013
Broadband photon time of flight spectroscopy: advanced spectroscopic analysis for ensuring safety and performance of pharmaceutical tablets

We report on extended spectroscopic analysis of pharmaceutical tablets performed with broadband photon time-of-flight absorption/scattering spectroscopy. Precise monitoring of absorption and scattering spectra enables cost-efficient monitoring of key safety and performance parameters of the drugs.

Building damage assessment after the earthquake in Haiti using two post-event satellite stereo imagery and DSMs

In this paper, a novel disaster building damage monitoring method is presented. This method combines the multispectral imagery and DSMs from stereo matching to obtain three kinds of changes. The proposed method contains three basic steps. The first step is to segment the panchromatic images to get the smallest possible homogeneous regions. In the second step, based on a rule based classification using change information from Iteratively Reweighted Multivariate Alteration Detection (IR-MAD) and height, the changes are classified to ruined buildings, new buildings, and changes without height change (mainly temporary residential area, etc. tents). In the last step, a region based grey level co-occurrence matrix texture measurement is used to refine the third change class. The method is applied to building change detection after the Haiti earthquake.
Challenges in 3D scanning: Focusing on Ears and Multiple View Stereopsis

It is the goal of this thesis to address some of the challenges in 3D scanning. This has been done with focus on direct in-ear scanning and on Multiple View Stereopsis. Seven papers have been produced over the course of the Ph.D., out of which, six have been included. Two papers concern volumetric segmentation based on Markov Random Fields. These have been formulated to address problems relating to noise filtering in direct in-ear scanning and Intracranial Volume estimation. Another two papers have been produced on the topic of recovering surface data based on a strong statistical prior. This was done in particular on scans of ear canals, but the methods are general. Finally, an experimental setup has been constructed, which has produced a large versatile data set. The data set has been used as the foundation for two papers on the evaluation of Multiple View Stereopsis. The data have a great potential to be used for advances in Multiple View Stereopsis, robust surface reconstruction and photorealistic modelling.

General information
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Contextual Multivariate Segmentation of Pork Tissue from Grating-Based Multimodal X-Ray Tomography

X-ray computed tomography is increasingly used as a nondestructive method for studying three dimensional food structures. For meat products, studies have focused mainly on fat and protein content due to limited contrast capabilities of absorption based techniques. Recent advances in X-ray imaging have made novel X-ray image modalities available, where the refraction and scattering of X-rays is obtained simultaneously with the absorption properties, providing enhanced contrast for soft biological tissues. This paper demonstrates how data obtained from grating-based imaging can be segmented by means of multivariate and contextual methods to improve the classification of soft tissues in meat products. The results show that the presented segmentation method provides improved classification over univariate segmentation.

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Correlation of iris biometrics and DNA

The presented work concerns prediction of complex human phenotypes from genotypes. We were interested in correlating iris color and texture with DNA. Our data consist of 212 eye images along with DNA: 32 single-nucleotide polymorphisms (SNPs). We used two types of biometrics to describe the eye images: One for iris color and one for iris texture. Both biometrics were high dimensional and a sparse principle component analysis (SPCA) reduced the dimensions and resulted in a representation of data with good interpretability. The correlations between the sparse principal components (SPCs) and the 32 SNPs were found using a canonical correlation analysis (CCA). The result was a single significant canonical correlation (CC) for both biometrics. Each CC comprised two correlated canonical variables, consisting of a linear combination of SPCs and a linear combination of SNPs, respectively. The significant canonical variables for color and texture were primarily explained by the first SPC (SPC1). Therefore, we made a visual inspection of the first SPCs. The color based SPC1 explained a blue to brown variation in iris color and the texture based SPC1 gave a general explanation of iris texture. The SNPs (rs12896399, rs3733542, rs6475555, rs12913832) and (rs12896399, rs3733542, rs12913832) had the highest correlation to the canonical variable for color and texture, respectively. Three of the most contributing SNPs were the same for both biometrics, revealing a covariance between iris color and texture.

DCT-Based Characterization of Milk Products Using Diffuse Reflectance Images

We propose to use the two-dimensional Discrete Cosine Transform (DCT) for decomposition of diffuse reflectance images of laser illumination on milk products in different wavelengths. Based on the prior knowledge about the characteristics of the images, the initial feature vectors are formed at each wavelength. The low order DCT coefficients are used to quantify the optical properties. In addition, the entropy information of the higher order DCT coefficients is used to include the illumination interference effects near the incident point. The discrimination powers of the features are computed and used to do wavelength and feature selection. Using the selected features of just one band, we could characterize and discriminate eight different milk products. Comparing this result with the current characterization method based of a fitted log-log linear model, shows that the proposed method can discriminate milk from yogurt products better.
Decomposition of Diffuse Reflectance Images - Features for Monitoring Structure in Turbid Media

Light scattering in turbid media can be related to the microstructure of media. Thus, light scattering can potentially be used for process control of products where the structure is a key component. However, process control requires robust and sensitive input data to function properly. In this study, we investigate different decomposition methods for extracting light scattering information from images of diffuse reflectance. Both well-established theoretical methods and data-driven methods are considered and evaluated based on their robustness and sensitivity to changes in light scattering properties.

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Determination of magnetic resonance imaging biomarkers for multiple sclerosis treatment effects

This thesis describes methods for deriving multiple sclerosis (MS) biomarkers from Magnetic resonance images (MRI).

MS results in a neurodegenerative disease course to which MRI has proven sensitive. In particular, diffusion MRI (dMRI), a modality reflecting microstructural properties of brain tissue has shown sensitivity towards the disease pathology of MS. We introduce three different methods for analysing MRI/dMRI in the white matter (WM) tracts, of an MS population. One method detects groupwise, tract-oriented differences based on features of the local diffusion tensor model. The next method, anatomical connectivity mapping (ACM) reflects voxel-wise whole-brain connectivity and is used to investigate cross-sectional disease-related connectivity alterations. The third method presented is a voxel-based segmentation method able to detect WM abnormalities (WM lesions), with the potential of being used as lesion load markers often reported in clinical studies.

The main result of the first method is statistical differences between healthy controls and MS patients in 11 WM tracts. The ability to distinguish the clinically defined subtypes of relapse remitting and secondary progressive MS patients is found based on the ACM method. Using ACM, localized statistical differences were detected in the bilateral motor tracts. The most interesting result of the lesion segmentation method study, was that it achieved a segmentation performance which was better than two competing methods relative to the manual segmentations of the radiographers.

The methods presented in the thesis are useful in studies of MS and are expected to have widespread applications in neuroscience.

General information
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Differences in Radiotherapy Delivery and Outcome Due to Contouring Variation

Gross tumor volume (GTV) delineation is central for radiotherapy planning. It provides the basis of the clinical target volume and, ultimately, the planning target volume which is used for dose optimization. Manual GTV delineations are prone to intra- and inter-observer variation and automatic segmentation methods also produce different results. There is no consensus on how to account for the contouring uncertainty, but has been suggested to incorporate it into the planning target volume (PTV) margin. Current recipes for the PTV margin are based on normal distribution assumptions and are more suitable for setup and execution errors. In this study we use the GTV delineations made by 6 experienced clinicians to create delineation-specific dose plans. These dose plans are then used to calculate theoretic tumor control probabilities (TCP) differences between delineations. The results show that current margin recipes are inadequate for maintaining the same TCP despite manual delineation variation. New methods to account for delineation variation should be developed.

General information
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Differential effects of aerobic exercise on insulin-stimulated glucose uptake in skeletal muscle and adipose tissue examined with PET/CT

General information
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Dynamically constrained pipeline for tracking neural progenitor cells

Large scale in vitro cell growth experiments require automated segmentation and tracking methods to construct cell lineages in order to aid cell biologists in further analysis. Flexible segmentation algorithms that easily adapt to the specific type of problem at hand and directly applicable tracking methods are fundamental building blocks of setting up multi purpose pipelines. Segmentation by discriminative dictionary learning and a graph formulated tracking method constraining the allowed topology changes are combined here to accommodate for highly irregular cell shapes and movement patterns. A mitosis detector constructed from empirical observations of cells in a pre-mitotic state interacts with the graph formulation to dynamically allow for cell mitosis when appropriate. Track consistency is ensured by introducing pragmatic constraints and the notion of blob states. We validate the proposed pipeline by tracking pig neural progenitor cells through a time lapse experiment consisting of 825 images collected over 69 hours. Each step of the tracking pipeline is validated separately by comparison with manual annotations. The number of tracked cells increase from approximately 350 to 650 during the time period.
Effect of fat type and heat treatment on the microstructure of meat emulsions

In comminuted meat products the gel-forming abilities of the myofibrillar proteins are of major importance. In meat emulsions fat will be present in globules which are stabilized by a membrane coating made of salt-soluble proteins. These discontinuous fat particles act as fillers or co-polymers and stabilize the protein network. Differences in the physicochemical properties of saturated and unsaturated lipids affect the distribution of fat and thereby the functionality and quality of the final product. The objectives were to study the effects of lipid type and heat treatment on changes in microstructure of meat emulsions by use of a novel quantitative application of absorption- and phase-contrast tomography. The non-invasive technique offered the possibility to study the same sample in both raw and cooked condition. The samples were raw and heat treated meat emulsions (10% protein, 25% fat, 60% moisture) prepared with either pork fat or sunflower oil. The tomograms were obtained at a synchrotron facility using a grating interferometer which measured three different properties in the sample simultaneously: The attenuation length, the electron density and the diffusion length. Phase contrast imaging of the tomograms were used to analyse the impact of lipid type on spatial fat distribution, microstructure of the protein network and structural changes caused by heat treatment. The tomograms showed that the fat distribution in the meat emulsions depended on the physicochemical properties of the added fat. Use of vegetable oil resulted in homogeneous emulsions with smaller fat globules compared to the use of pork fat. This has previously been shown by the use of light micrographs. However, with the use of phase contrast imaging it was, from the same image, possible to resolve the protein phase to obtain information about the quality of the protein network and of the changes in microstructure caused by heat treatment. Further it was possible to compare the amounts of cooking loss from the emulsions. In conclusion phase contrast imaging with its high spectral resolution offers a unique possibility for studies of microstructure and is superior to histology since the information is obtained for the full volume.
Facial Analysis: Looking at Biometric Recognition and Genome-Wide Association
The goal of this Ph.D. project is to present selected challenges regarding facial analysis within the fields of Human Biometrics and Human Genetics. In the course of the Ph.D. nine papers have been produced, eight of which have been included in this thesis.

Three of the papers focus on face and gender recognition, where in the gender recognition papers the process of human perception of gender is analyzed and used to improve machine learning algorithms.

One paper addresses the issues of variability in human annotation of facial landmarks, which most papers regard as a static “gold standard”. However, we document intra- and inter-operator variability associated with annotating these landmarks, which is a valuable result for applications that are sensitive to such variability.

One paper presents a comprehensive proof-of-concept study of the prediction of facial characteristics based solely on genetic information, a new area that holds great potential.

Two papers explore the connection between minor physical anomalies in the face and schizophrenic disorders. Schizophrenia is a life long disease, but early discovery and treatment can have a significant impact on the course of the disease.

Finally, one paper presents a novel appearance model that is a fusion of the active appearance models and the Riemannian elasticity framework.

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Fast and Practical Head Tracking in Brain Imaging with Time-of-Flight Camera
This paper investigates the potential use of Time-of-Flight cameras (TOF) for motion correction in medical brain scans. TOF cameras have previously been used for tracking purposes, but recent progress in TOF technology has made it relevant for high speed optical tracking in high resolution medical scanners. Particularly in MRI and PET, the newest generation of TOF cameras could become a method of tracking small and large scale patient movement in a fast and user friendly way required in clinical environments. We present a novel methodology for fast tracking from TOF point clouds without the need of expensive triangulation and surface reconstruction. Tracking experiments with a motion controlled head phantom were performed with a translational tracking error below 2mm and a rotational tracking error below 0.5°.

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Fast, Sequence Adaptive Parcellation of Brain MR Using Parametric Models

In this paper we propose a method for whole brain parcellation using the type of generative parametric models typically used in tissue classification. Compared to the non-parametric, multi-atlas segmentation techniques that have become popular in recent years, our method obtains state-of-the-art segmentation performance in both cortical and subcortical structures, while retaining all the benefits of generative parametric models, including high computational speed, automatic adaptiveness to changes in image contrast when different scanner platforms and pulse sequences are used, and the ability to handle multi-contrast (vector-valued intensities) MR data. We have validated our method by comparing its segmentations to manual delineations both within and across scanner platforms and pulse sequences, and show preliminary results on multi-contrast test-retest scans, demonstrating the feasibility of the approach.

Genetic analyses of the human eye colours using a novel objective method for eye colour classification

In this study, we present a new objective method for measuring the eye colour on a continuous scale that allows researchers to associate genetic markers with different shades of eye colour.

With the use of the custom designed software Digital Iris Analysis Tool (DIAT), the iris was automatically identified and extracted from high resolution digital images. DIAT was made user friendly with a graphical user interface. The software counted the number of blue and brown pixels in the iris image and calculated a Pixel Index of the Eye (PIE-score) that described the eye colour quantitatively. The PIE-score ranged from −1 to 1 (brown to blue). The software eliminated the need for user based interpretation and qualitative eye colour categories. In 94% (570) of 605 analyzed eye images, the iris region was successfully extracted and a PIE-score was calculated. A very high correlation between the PIE-score and the human perception of eye colour was observed. The correlations between the PIE-scores and the six IrisPlex SNPs (HERC2 rs12913832, OCA2 rs1800407, SLC24A4 rs12896399, TYR rs1393350, SLC45A2 rs16891982 and IRF4 rs12203592) were analyzed in 570 individuals. Significant differences (p < 10−6) in the PIE-scores of the individuals typed as HERC2 rs12913832 G (PIE = 0.99) and rs12913832 GA (PIE = −0.71) or A (PIE = −0.87) were observed. We adjusted
for the effect of HERC2 rs12913832 and showed that the quantitative PIE-scores were significantly associated with SNPs with minor effects (OCA2 rs1800407, SLC24A4 rs12896399 and TYR rs1393350) on the eye colour. We evaluated the two published prediction models for eye colour (IrisPlex [1] and Snipper[2]) and compared the predictions with the PIE-scores. We found good concordance with the prediction from individuals typed as HERC2 rs12913832 G. However, both methods had difficulties in categorizing individuals typed as HERC2 rs12913832 GA because of the large variation in eye colour in HERC2 rs12913832 GA individuals. With the use of the DIAT software and the PIE-score, it will be possible to automatically compare the iris colour of large numbers of iris images obtained by different studies and to perform large meta-studies that may reveal loci with small effects on the eye colour.

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Genus Zero Graph Segmentation: Estimation of Intracranial Volume

The intracranial volume (ICV) in children with premature fusion of one or more sutures in the calvaria is of interest due to the risk of increased intracranial pressure. Challenges for automatic estimation of ICV include holes in the skull e.g. the foramen magnum and fontanelles. In this paper, we present a fully automatic 3D graph-based method for segmentation of the ICV in non-contrast CT scans. We reformulate the ICV segmentation problem as an optimal genus 0 segmentation problem in a volumetric graph. The graph is the result of a volumetric spherical subsample from the data connected using Delaunay tetrahedralisation. A Markov Random Field is constructed on the graph with probabilities learned from an Expectation Maximisation algorithm matching a Mixture of Gaussians to the data. Results are compared to manual segmentations performed by an expert. We have achieved very high Dice scores ranging from 98.14% to 99.00%, while volume deviation from the manual segmentation ranges from 0.7%-3.7%. The Hausdorff distance, which shows the maximum error from automatic to manual segmentation ranges, from 4.73-9.81mm. Since this is sensitive to single error, we have also found the 95% Hausdorff distance, which ranges from 1.10-3.65mm. The proposed method is expected to perform well for other volumetric segmentations.

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Improved inference in Bayesian segmentation using Monte Carlo sampling: Application to hippocampal subfield volumetry

Many segmentation algorithms in medical image analysis use Bayesian modeling to augment local image appearance with prior anatomical knowledge. Such methods often contain a large number of free parameters that are first estimated and then kept fixed during the actual segmentation process. However, a faithful Bayesian analysis would marginalize over such parameters, accounting for their uncertainty by considering all possible values they may take. Here we propose to incorporate this uncertainty into Bayesian segmentation methods in order to improve the inference process. In particular, we approximate the required marginalization over model parameters using computationally efficient Markov chain Monte Carlo techniques. We illustrate the proposed approach using a recently developed Bayesian method for the segmentation of hippocampal subfields in brain MRI scans, showing a significant improvement in an Alzheimer's disease classification task. As an additional benefit, the technique also allows one to compute informative "error bars" on the volume estimates of individual structures.

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Improving Topology Optimization using Games

Topology optimization has had, and still has, a great impact on the design of structures and mechanical elements. Even though computers and topology optimization algorithms are able to find good solutions to most problems, it is also important for users of such programs to have a good intuition for whether a structure is optimal. We hypothesize that human intuition regarding topology optimization is often led astray. Our goal is to collect data in order to test this hypothesis and at the same time to actively train users (in particular students of mechanical engineering) in designing optimal structures. Consequently, we have created a game, the TopOptGame, which improves the player's topology optimization intuition in a fun and engaging way while collecting data about the users performance.

Technically, the TopOptGame builds on the TopOptApp [1] - an interactive topology optimization application designed for hand-held devices. The TopOptApp solves the 2D minimum compliance problem with interactive control of loads, supports and volume fraction, and thus the TopOptApp allows the user to change the problem on the y and watch the design evolve to a new optimum in real time. TopOptApp is available free of charge on iOS and Android devices.

The TopOptGame is inspired by puzzle-games (a genre of computer games), which constantly challenges the players and gives rewards when progress is made. This engagement loop will take the player on a journey starting with simple problems with few supports and a single load and gradually increase the difficulty by adding more loads, restrictions on the design domain, distributed loads and multiple load cases. The goal is to distribute material in a discretized design domain, under some volume and time constrains, while searching for a good solution (minimum compliance). A visualization of the strain energy density will help the player nding a feasible solution.

Besides training the player in topology optimization, the game also tracks the progress of each player and sends this progress in anonymized form to a database. When enough data has been collected, this will allow us to analyze the data to measure human performance of topology optimization and more importantly, in which cases people's intuition succeed or fail.

The game is currently a working prototype and is scheduled for final release on both iOS and Android before WCSMO-10.
Is Synthesizing MRI Contrast Useful for Inter-modality Analysis?
Availability of multi-modal magnetic resonance imaging (MRI) databases opens up the opportunity to synthesize different MRI contrasts without actually acquiring the images. In theory such synthetic images have the potential to reduce the amount of acquisitions to perform certain analyses. However, to what extent they can substitute real acquisitions in the respective analyses is an open question. In this study, we used a synthesis method based on patch matching to test whether synthetic images can be useful in segmentation and inter-modality cross-subject registration of brain MRI. Thirty-nine T1 scans with 36 manually labeled structures of interest were used in the registration and segmentation of eight proton density (PD) scans, for which ground truth T1 data were also available. The results show that synthesized T1 contrast can considerably enhance the quality of non-linear registration compared with using the original PD data, and it is only marginally worse than using the original T1 scans. In segmentation, the relative improvement with respect to using the PD is smaller, but still statistically significant.

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List-Mode PET Motion Correction Using Markerless Head Tracking: Proof-of-Concept With Scans of Human Subject

A custom designed markerless tracking system was demonstrated to be applicable for positron emission tomography (PET) brain imaging. Precise head motion registration is crucial for accurate motion correction (MC) in PET imaging. State-of-the-art tracking systems applied with PET brain imaging rely on markers attached to the patient's head. The marker attachment is the main weakness of these systems. A healthy volunteer participating in a cigarette smoking study to image dopamine release was scanned twice for 2 h with $^{11}\text{C}$-raclopride on the high resolution tomograph (HRRT) PET scanner. Head motion was independently measured, with a commercial marker-based device and the proposed vision-based system. A list-mode event-by-event reconstruction algorithm using the detected motion was applied. A phantom study with hand-controlled continuous random motion was obtained. Motion was time-varying with long drift motions of up to 18 mm and regular step-wise motion of 1–6 mm. The evaluated measures were significantly better for motion-corrected images compared to no MC. The demonstrated system agreed with a commercial integrated system. Motion-corrected images were improved in contrast recovery of small structures.

General information
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Modeling of Craniofacial Anatomy, Variation, and Growth

The topic of this thesis is automatic analysis of craniofacial images with respect to changes due to growth and surgery, inter-subject variation and intracranial volume estimation. The methods proposed contribute to the knowledge about specific craniofacial anomalies, as well as provide a tool for detailed analyses for clinical and research purposes.

Most of the applications in this thesis rely on non-rigid image registration by the means of warping one image into the coordinate system of another image. This warping results in a deformation field that describes the anatomical correspondence between the two images. To elaborate further: a computational atlas of the average anatomy was constructed. Using non-rigid registration, image data from a subject is automatically transformed into the coordinate space of the atlas. In this process, all knowledge built into the atlas is transferred to the subject, thus creating a personalized atlas. The knowledge built into the atlas is e.g. location of anatomical regions and landmarks of importance to surgery planning and evaluation or population studies. With these correspondences, various analyses could be carried out e.g. quantification of growth, inter-subject variation etc. Besides image registration, a volumetric segmentation method using graph cuts was developed and applied for intracranial volume estimation. Graph cut is a fast method for segmentation utilizing a suitable graph.

Three different craniofacial anomalies were examined in this thesis: Cleft lip and palate, unicoronal synostosis, and Crouzon syndrome. Using the proposed methods, highly detailed variation was assessed for cleft lip and palate, correspondence between images obtained before and after lip repair was established for cleft lip and palate, the intracranial volume was estimated for infants with unicoronal synostosis, and finally, craniofacial growth patterns were quantified for Crouzon syndrome in a mouse model.

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On Feature Relevance in Image-Based Prediction Models: An Empirical Study

Determining disease-related variations of the anatomy and function is an important step in better understanding diseases and developing early diagnostic systems. In particular, image-based multivariate prediction models and the "relevant features" they produce are attracting attention from the community. In this article, we present an empirical study on the relevant features produced by two recently developed discriminative learning algorithms: neighborhood approximation forests (NAF) and the relevance voxel machine (RVoxM). Specifically, we examine whether the sets of features these methods produce are exhaustive; that is whether the features that are not marked as relevant carry disease-related information. We perform experiments on three different problems: image-based regression on a synthetic dataset for which the set of relevant features is known, regression of subject age as well as binary classification of Alzheimer's Disease (AD) from brain Magnetic Resonance Imaging (MRI) data. Our experiments demonstrate that aging-related and AD-related variations are widespread and the initial sets of relevant features discovered by the methods are not exhaustive. Our findings show that by knocking-out features and re-training models, a much larger set of disease-related features can be identified.

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Online Multi-Spectral Meat Inspection

We perform an explorative study on multi-spectral image data from a prototype device developed for fast online quality inspection of meat products. Because the camera setup is built for speed, we sacrifice exact pixel correspondences between the different bands of the multi-spectral images.

Our work is threefold as we 1) investigate the color distributions and construct a model to describe pork loins, 2) classify the different components in pork loins (meat, fat, membrane), and 3) detect foreign objects on the surface of pork loins. Our investigation shows that the color distributions can effectively be modeled using the Gaussian mixture model (GMM). For the classification task we build a classifier using a GMM. For detecting foreign objects, we construct a novelty detector using a GMM.

We evaluate our method on a small dataset with mixed results. While we are able to provide reasonable classifications, the multi-spectral data does not seem to offer significant additional information compared to a standard RGB camera. Moreover, the multi-spectral images come with the cost of losing pixel correspondences.
Pond of Illusion: Interacting through Mixed Reality

Pond of Illusion is a mixed reality installation where a virtual space (the pond) is injected between two real spaces. The users are in either of the real spaces, and they can see each other through windows in the virtual space as illustrated in Figure 1(left). The installation attracts people to a large display in either of the real spaces by allowing them to feed virtual fish swimming in the pond. Figure 1(middle) shows how a Microsoft Kinect mounted on top of the display is used for detecting throw motions, which triggers virtual breadcrumbs to be thrown into the pond for feeding the nearby fish. Of course, the fish may not be available because they are busy eating what people have thrown into the pond from the other side.

PorkCAD: Case study of the design of a pork product prototyper

With the help of industry experts we developed porkCAD, an application intended to aid in the communication process between producer and retailer when developing new meat products for a constantly evolving market. The application interface allows the user to make planar cuts to a virtual pig formed from CT-scans of a real-world pig carcass. We present a case study of the design process from conceptualization to intended introduction into the work flow of a meat production company. We discuss critical design decisions during development and present perspectives for future development.
To determine the usability of porkCAD, we tested it with personnel from the pork industry, using two different controller interfaces, one being a traditional mouse and keyboard input, and the other a six degrees of freedom haptic feedback device. The accurate depiction of pig anatomy guided trained professionals to re-create standardized pig products using porkCAD. The quantitative results of the usability test with sales personnel did not lean significantly in favor of either interface.

Since one interface was extremely well known and the other highly unfamiliar, the fact that users did not express a clear preference for the known input modality is deemed important. We report on the observed user experience regarding the two interfaces.
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Morphometry, Mesocortex, Alzheimer's disease, Localization
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Quantification of Tissue Trauma following Insulin Pen Needle Insertions in Skin

Objective:
Within the field of pen needle development, most research on needle design revolves around mechanical tensile testing and patient statements. Only little has been published on the actual biological skin response to needle insertions. The objective of this study was to develop a computational method to quantify tissue trauma based on skin bleeding and immune response.

Method:
Two common sized pen needles of 28G (0.36mm) and 32G (0.23mm) were inserted into skin of sedated LYD pigs prior to termination. Four pigs were included and a total of 32 randomized needle insertions were conducted. The affected tissue was removed and fixed in formalin following tissue preparation for histology. Standard immunohistochemical staining procedure was applied with CD-45 and anti-hemoglobin primary antibodies to stain immune cells and red blood cells, respectively. The stained tissue slides were subsequently digitized using 200X magnification. Based on thresholding, morphological masks and blob detection, segmentation of the histology was performed to locate tissue bleeding and immune response. Image-to-image registration was used on images originating from the same tissue, and a quantitative measure of tissue trauma was obtained for each needle insertion.

Result:
Bleeding and immune response were seen for all tested needles. Positive correlation was seen between the needle diameter and the size of the bleeding. The quantitative measure reveal a trend that tissue trauma decreases with decreasing needle diameter.

Conclusion:
A computational and quantitative method has been developed to assess tissue trauma following insulin pen needle insertions. Application of the method is tested by conduction of a needle diameter study. The obtained quantitative measures of tissue trauma correlate positively to needle diameter.

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Spectral characterisation of dairy products using photon time-of-flight spectroscopy

In this paper, we present, for the first time, the absorption and reduced scattering spectra of commercially available milk and yoghurt products, obtained using photon-time-of-flight spectroscopy. The ability of this technique to separate the contributions from absorption and scattering in the sample provides important information on the chemical composition and micro-structural properties, which are not available with the traditional techniques used in dairy production. The instrument operates in the spectral range from 500 nm to 1030 nm. The reduced scattering coefficient varies from 5 cm\(^{-1}\) for milk with 0.1% fat in the near infrared range, to 60 cm\(^{-1}\) for yoghurt with 3.0% fat in the green wavelength regime. The absorption is within the range of 0.05-0.5 cm\(^{-1}\), with only small variation in the absolute value between products. Our results show that the reduced scattering clearly distinguishes milk and yoghurt with the same fat content and can offer a reliable way of monitoring structural formation during milk fermentation.
Strength training and testosterone treatment have opposing effects on migration inhibitor factor levels in ageing men
Strength Training and Testosterone Treatment Have Opposing Effects on Migration Inhibitor Factor Levels in Ageing Men

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Structured Light-Based Motion Tracking in the Limited View of an MR Head Coil

A markerless motion tracking (MT) system developed for use in PET brain imaging has been tested in the limited field of view (FOV) of the MR head coil from the Siemens Biograph mMR. The system is a 3D surface scanner that uses structured light (SL) to create point cloud reconstructions of the facial surface. The point clouds are continuously realigned to a reference scan to obtain pose estimates. The system has been tested on a mannequin head performing controlled rotational and translational axial movements within the head coil outside the range of the magnetic field. The RMS of the residual error of the rotation was 0.11° and the RMS difference in the translation with the control system was 0.17 mm, within the trackable range of movement.
The genetics of eye colours in an Italian population measured with an objective method for eye colour quantification

Brown and blue eye colours are primarily explained by the single nucleotide polymorphism (SNP) HERC2 rs12913832. However, the genetics of eye colours that appear to be neither blue nor brown are not well understood. In this study, 230 unrelated Italian individuals were typed for 32 SNP loci in pigmentary genes. High resolution digital images of the participants’ eyes were taken and the iris region was successfully extracted with the use of the custom designed software Digital Iris Analysis Tool (DIAT) from 218 of the 230 (95%) images. The software counted the numbers of blue and brown pixels in the iris region and calculated a Pixel Index of the Eye (PIE-score) that described the eye colours quantitatively. The PIE-score ranged from -1 to 1 (brown to blue). We investigated the association of the PIE-scores extracted from the eye images with the genotypes of the 32 pigmentary SNPs. We observed a statistically significant association between the PIE-scores and the SNP loci rs12913832, rs4778241, rs7495174 in the HERC2/OCA2 region and the locus rs16891982 in SLC45A2.

The Improved Relevance Voxel Machine

The concept of sparse Bayesian learning has received much attention in the machine learning literature as a means of achieving parsimonious representations of features used in regression and classification. It is an important family of algorithms for sparse signal recovery and compressed sensing and enables basis selection from overcomplete
One of the trailblazers of Bayesian learning is MacKay who already worked on the topic in his PhD thesis in 1992 [1]. Later on Tipping and Bishop developed the concept of sparse Bayesian learning [2, 3] and Tipping published the Relevance Vector Machine (RVM) [4] in 2001. While the concept of RVM was intriguing, problems with the approach were the run time which is approximately cubic in the number of basis functions as well as the greedy optimization. Hence, different approaches to overcome these shortcomings were developed, e.g. [5] or [6] as well as Tipping himself in [7] (FastRVM).

Recently, Sabuncu and Van Leemput [8, 9] extended the relevance vector machine by incorporating an additional spatial regularization term in the Gaussian prior on the regression weights or classification features (RVoxM). RVoxM encourages spatial clustering of the relevance voxels and computes predictions as linear combinations of their content. While the model of RVoxM produced nice results on age regression data [8, 9], the algorithm used a simple fixed point optimization scheme, which is not guaranteed to decrease the cost function at every step and is computationally expensive. In addition, RVoxM prunes voxels from the regression model by applying an artificial numerical threshold to the weight hyperparameters and hence has a free parameter that influences model sparsity. Finally, RVoxM can only remove voxels from the model, but not reintroduce them later on. Hence in its current form it is reminiscent of a greedy forward feature selection algorithm.

In this report, we aim to solve the problems of the original RVoxM algorithm in the spirit of [7] (FastRVM). We call the new algorithm Improved Relevance Voxel Machine (IRVoxM). Our contributions are an improvement of the greedy optimization algorithm employed in RVoxM by exploiting the form of the marginal likelihood function and deriving an analytic expression for the optimal hyperparameter of each voxel, given the current hyperparameter of all other voxels. This enables us to maximize the marginal likelihood function in a principled and efficient manner. As a result IRVoxM optimizes the objective function better during training and the resulting models predict better on unseen cases. Finally, IRVoxM enables us to flexibly add and/or remove voxels during the optimization procedure.
**Topology Optimization using an Explicit Interface Representation**

Current methods for topology optimization primarily represent the interface between solid and void implicitly on fixed grids. In contrast, shape optimization methods represent the interface explicitly, but do not allow for any topological changes to the structure. Using an explicit interface representation has a number of advantages as described below. Consequently, we propose to use the Deformable Simplicial Complex (DSC) method [1] which represents the interface explicitly as one or more closed piecewise linear curves in 2D.

As opposed to pure shape optimization methods, the DSC method is able to handle topology changes. It does so by discretizing the entire design domain into an irregular adaptive triangle mesh and thereby explicitly representing both the structure and the embedding space. In other words, the entire design domain is divided into triangles, where the interface is represented as piecewise linear curves between void and non-void triangles.

Another advantage of the DSC method is that we can exploit the triangle mesh for the FEM computations used in the optimization procedure. The non-void elements define the structure and their deformation is described by second order shape functions. To increase performance, degrees of freedom associated with void triangles are eliminated from the FE equation. Using the triangle mesh for computations is possible since the DSC method ensures a mesh with no degenerate elements. If the mesh contained degenerate or close to degenerate elements the FEM computations would break down and the results would no longer be valid. The DSC method solves this issue by a series of mesh operations which keeps the mesh ever well-formed. Put another way, the consequence of using a well-formed adaptive mesh is that the representation for the FEM calculations and the shape of the structure can be one and the same.

In addition to unifying calculations and representation of the structure, the approach also unifies shape and topology optimization into a single framework. Furthermore, it combines the two in a simultaneous optimization strategy. Here, the shape is optimized on the basis of the gradient based optimization algorithm Method of Moving Asymptotes whereas holes are introduced using topological derivatives. Since we combine these methods, and since FEM calculations are performed only on non-void triangles and gradients are calculated only for the interface nodes, the presented approach is efficient.

An explicit representation is not just useful when considering simplicity and performance. In many cases, the explicitly represented interface is necessary to be able to model a problem. For example for ow or electromagnetic problems with localized boundary effects. Furthermore, control of boundary smoothness is simple to implement and can e.g. be used to control fillet radius at corners. The method also opens up for the opportunity to apply other local constraints, such as min/max length scale of the structure. Finally, the explicit interface is in all cases necessary when interpreting the final design. The status of the work is that the method has been developed and is showing promising results. For instance, the cantilever beam problem has been solved to a high precision using a fine discretization by evaluating the objective function approximately 500 times. This took around 100 seconds on an ordinary laptop utilizing a single thread. In addition, a coarse solution to the same problem has been obtained in approximately 10 seconds.

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**Tract-oriented statistical group comparison of diffusion in sheet-like white matter**

Identifying specific structures of the brain where pathology differs between groups of subjects may aid to develop imaging-based markers for disease diagnosis. We propose a new technique for doing multivariate statistical analysis on white matter tracts with sheet-like shapes. Previous works assume tube-like shapes, not always suitable for modelling the white matter tracts of the brain. The tract-oriented technique aimed at group studies, integrates the usage of multivariate features and outputs a single value of significance indicating tract-specific differences. This is in contrast to voxel based analysis techniques which outputs a significance per voxel basis, and requires multiple comparison correction. We demonstrate our technique by comparing a group of controls with a group of Multiple Sclerosis subjects obtaining significant differences on 11 different fascicle structures.
Using leverages for objective analysis of PSMSL tide gauges in Arctic Ocean sea level reconstruction

Using Multispectral Imaging for Spoilage Detection of Pork Meat

Using Multispectral Imaging for Spoilage Detection of Pork Meat
The quality of stored minced pork meat was monitored using a rapid multispectral imaging device to quantify the degree of spoilage. Bacterial counts of a total of 155 meat samples stored for up to 580 h have been measured using conventional laboratory methods. Meat samples were maintained under two different storage conditions: aerobic and modified atmosphere packages as well as under different temperatures. Besides bacterial counts, a sensory panel has judged the spoilage degree of all meat samples into one of three classes. Results showed that the multispectral imaging device was able to classify 76.13% of the meat samples correctly according to the defined sensory scale. Furthermore, the multispectral camera device was able to predict total viable counts with a standard error of prediction of 7.47%. It is concluded that there is a good possibility that a setup like the one investigated will be successful for the detection of spoilage degree in minced pork meat.

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Using X-ray imaging to study thermal-induced changes in food

The food quality in many food processes relies greatly on the structural changes that take place during heating or freezing of the food product. So far, it has only been possible to study these changes indirectly but recent new X-ray imaging modalities allow for direct visualization. We present preliminary results of structural changes by heating of bovine meat and freezing of berries inspected with X-ray phase-contrast and dark-field imaging.
Utilization of Multispectral Images for Meat Color Measurements

This short paper describes how the use of multispectral imaging for color measurement can be utilized in an efficient and descriptive way for meat scientists. The basis of the study is meat color measurements performed with a multispectral imaging system as well as with a standard colorimeter. It is described how different color spaces can enhance the purpose of the analysis - whether that is investigation of a single sample or a comparison between samples. Moreover the study describes how a simple segmentation can be applied to the multispectral images in order to reach a more descriptive measure of color and color variance than what is obtained by the standard colorimeter.

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Imaging Food Quality

Imaging and spectroscopy have long been established methods for food quality control both in the laboratories and online. An ever increasing number of analytical techniques are being developed into imaging methods and existing imaging methods to contain spectral information. Images and especially spectral images contain large amounts of data which should be analysed appropriately by techniques combining structure and spectral information.

This dissertation deals with how different types of food quality can be measured by imaging techniques, analysed with appropriate image analysis techniques and finally use the image data to predict or visualise food quality.

A range of different food quality parameters was addressed, i.e. water distribution in bread throughout storage, time series analysis of chocolate milk stability, yoghurt glossiness, graininess and dullness and finally structure and meat colour of dry fermented sausages. The imaging techniques ranged from single wavelength images, multispectral to hyperspectral images. The effect of different light geometries were utilised in measuring the light reflection of yoghurt surfaces.

What the best imaging technique for a given problem is, should be addressed by visually evaluation of a detectable difference between known samples. While doing image analysis, it was found to be advantageous to combine several small models. The combined model was used for extraction of object relevant information, i.e. spectral, texture or size. The data extracted was used for explorative or predictive data analysis.
Joint Modelling of Structural and Functional Brain Networks

Functional and structural magnetic resonance imaging have become the most important noninvasive windows to the human brain. A major challenge in the analysis of brain networks is to establish the similarities and dissimilarities between functional and structural connectivity. We formulate a non-parametric Bayesian network model which allows for joint modelling and integration of multiple networks. We demonstrate the model's ability to detect vertices that share structure across networks jointly in functional MRI (fMRI) and diffusion MRI (dMRI) data. Using two fMRI and dMRI scans per subject, we establish significant structures that are consistently shared across subjects and data splits. This provides an unsupervised approach for modeling of structure-function relations in the brain and provides a general framework for multimodal integration.

3D Surface Scanner Using Structured Light & Industrial Robot

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