Visual Human-Computer Interaction

In the recent years, technologies such as Virtual and Augmented Reality have 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.

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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 anthropology, 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%.

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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.
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.
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.

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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 subjects 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.

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.
Image Analysis for X-ray Imaging of Food

X-ray imaging systems are increasingly used for quality and safety evaluation both within food science and production. They offer non-invasive and nondestructive penetration capabilities to image the inside of food.

This thesis presents applications of a novel grating-based X-ray imaging technique for quality and safety evaluation of food products. In this effort the fields of statistics, image analysis and statistical learning are combined, to provide analytical tools for determining the aforementioned food traits.

The work demonstrated includes a quantitative analysis of heat induced changes in microstructure of meat products. A segmentation framework is presented, from which geometrical parameters are assessed. The grating-based method embraces the complicated microstructure of the meat products, allowing for an analysis of the full three dimensional structure. The results illustrate that the combination of grating-based X-ray imaging and advanced analysis provides a valuable tool for microstructure analysis. Thus, the method can be considered as an alternative to other existing imaging techniques.

Furthermore, the thesis presents the application of grating-based X-ray imaging for novelty and defect detection in food. Compared to the complex three dimensional analysis of microstructure, here two dimensional images are considered, making the method applicable for an industrial setting. The advantages obtained by grating-based imaging are compared to conventional X-ray imaging, for both foreign object and defect detection. The results further emphasize the applicability of grating-based imaging for evaluation of food quality and food safety.

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Influence of Maturation, Pathology and Functional Lateralization on 3D Sulcal Morphology using MRI

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.

**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.
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.
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.
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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

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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.
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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.

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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.

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An MRI Compatible Surface Scanner

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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.

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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 ($\Omega$) 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.
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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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
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.
**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**
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Organisations: Image Analysis & Computer Graphics, Department of Applied Mathematics and Computer Science, Odense University Hospital, University of Southern Denmark, Statens Serum Institut, Aalborg University
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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.
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.

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Organisations: Department of Applied Mathematics and Computer Science, National Food Institute, Research Group for Food Production Engineering, Image Analysis & Computer Graphics, Dublin City University, Arla Strategic Innovation Center, DuPont Nutrition Biosciences Aps
Authors: Skytte, J. L. (Intern), Ghita, O. (Ekstern), Whelan, P. F. (Ekstern), Andersen, U. (Ekstern), Moller, F. (Intern), Dahl, A. B. (Intern), Larsen, R. (Intern)
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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.

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General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, National Food Institute, Research Group for Food Production Engineering, Image Analysis & Computer Graphics, Dublin City University, Arla Strategic Innovation Center, DuPont Nutrition Biosciences Aps
Authors: Skytte, J. L. (Intern), Ghita, O. (Ekstern), Whelan, P. F. (Ekstern), Andersen, U. (Ekstern), Moller, F. (Intern), Dahl, A. B. (Intern), Larsen, R. (Intern)
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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
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Scopus rating (2008): SJR 0.886 SNIP 0.924
Scopus rating (2007): SJR 0.695 SNIP 0.966
Web of Science (2007): Indexed yes
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Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.743 SNIP 1.025
Web of Science (2004): Indexed yes
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Web of Science (2003): Indexed yes
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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

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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.
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.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Vestergaard, J. S. (Intern), Larsen, R. (Intern), Nielsen, A. A. (Intern)
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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
Non-Invasive Assessment of Dairy Products Using Spatially Resolved Diffuse Reflectance Spectroscopy

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.
The number of genes controlling mimetic traits has been a topic of much research and discussion. In this paper, we examine a mimetic, dendrobatid frog *Ranitomeya imitator*, which harbours extensive phenotypic variation with multiple mimetic morphs, not unlike the celebrated *Heliconius* system. However, the genetic basis for this polymorphism is unknown, and not easy to determine using standard experimental approaches, for this hard-to-breed species. To circumvent this problem, we first develop a new protocol for automatic quantification of complex colour pattern phenotypes from images. Using this method, which has the potential to be applied in many other systems, we define a phenotype associated with differences in colour pattern between different mimetic morphs. We then proceed to develop a maximum-likelihood method for estimating the number of genes affecting a quantitative trait segregating in a hybrid zone. This method takes advantage of estimates of admixture proportions obtained using genetic data, such as microsatellite markers, and is applicable to any other system where a phenotype has been quantified in an admixture/introgression zone. We evaluate the method using extensive simulations and apply it to the *R. imitator* system. We show that probably one or two, or at most three genes, control the mimetic phenotype segregating in a *R. imitator* hybrid zone identified using...
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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.

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

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Authors: Anker, C. (Ekstern), Pai, A. (Ekstern), Sørensen, L. (Ekstern), Lyksborg, M. (Intern), Larsen, R. (Intern), Conradsen, K. (Intern), Nielsen, M. (Ekstern)
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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 processes. 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 processes 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.
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.
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.

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Authors: Jensen, R. R. (Intern), Thorup, S. S. (Intern), Paulsen, R. R. (Intern), Darvann, T. A. (Ekstern), Hermann, N. V. (Ekstern), Larsen, P. (Ekstern), Kreiborg, S. (Ekstern), Larsen, R. (Intern)
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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.
Quantification Tools for Analyzing Tomograms of Energy Materials

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. It is not feasible to segment manually, this could take months.

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.

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Authors: Emerson, M. J. (Intern), Dahl, A. B. (Intern), Larsen, R. (Intern)
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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), 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.

General information
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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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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Statistics and Data Analysis
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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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**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; Pfeiffer 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.

**General information**

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

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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.

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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.

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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.

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.
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').

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 than 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.
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.

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.
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.

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.

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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 multipurpose 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.

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**Organisations:** Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Technical University of Denmark, University of Copenhagen
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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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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Copenhagen University Hospital
Authors: Wilm, J. (Intern), Olesen, O. V. (Intern), Jensen, R. R. (Intern), Højgaard, L. (Forskerdatabase), Larsen, R. (Intern)
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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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Authors: Jensen, R. R. (Intern), Thorup, S. S. (Intern), Paulsen, R. R. (Intern), Darvann, T. A. (Ekstern), Hermann, N. V. (Ekstern), Larsen, P. (Ekstern), Kreiborg, S. (Forskerdatabase), Larsen, R. (Intern)
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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 $^{11}$C-raclopride on the high resolution research 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.
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.

General information

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Authors: Thorup, S. S. (Intern), Larsen, R. (Intern), Darvann, T. A. (Intern), Paulsen, R. R. (Intern)
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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.

Quantitative Analysis of Micro-Structure in Meat Emulsions from Grating-Based Multimodal X-Ray Tomography
Using novel X-ray techniques, based on grating-interferometry, new imaging modalities can be obtained simultaneously with absorption computed tomography (CT). These modalities, called phase contrast and dark field imaging, measure the electron density and the diffusion length of the sample. Enhanced contrast capabilities of this X-ray technique makes studies on materials with similar attenuation properties possible. In this paper the focus is set on processing grating-based X-ray tomograms of meat emulsions to quantitatively measure micro-structural changes due to heat treatment. 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 micro-structural differences when either pork fat or sunflower oil was used. From the reconstructed tomograms the different ingredients 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 percentage object volumes and cooking loss. Additionally, the porosity, degree of anisotropy and average structure thickness of the protein networks were determined. Analyzing the multivariate dataset instead of the single univariate absorption modality gave superior segmentation results. The quantitative analysis of the micro-structure gives insight to how both heat treatment, and the use of different lipid types, affect the final protein network.

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Authors: Jensen, C. B. (Ekstern), Larsen, R. (Intern), Vestergaard, J. S. (Intern), Conradsen, K. (Intern), Kildegaard, J. (Ekstern), Præstmark, K. A. (Ekstern)
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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

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Odense University Hospital, University of Southern Denmark, Statens Serum Institut, Aarhus University
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Scopus rating (2009): SJR 0.647 SNIP 0.736
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Scopus rating (2008): SJR 0.612 SNIP 0.668
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.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Technical University of Denmark, Copenhagen University Hospital
Authors: Erikshøj, M. (Forskerdatabase), Olesen, O. V. (Intern), Conradsen, K. (Intern), Højgaard, L. (Ekstern), Larsen, R. (Intern)
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Three-dimensional MRI-linac intra-fraction guidance using multiple orthogonal cine-MRI planes

The introduction of integrated MRI-radiation therapy systems will offer live intra-fraction imaging. We propose a feasible low-latency multi-plane MRI-linac guidance strategy. In this work we demonstrate how interleaved acquired, orthogonal cine-MRI planes can be used for low-latency tracking of the 3D trajectory of a soft-tissue target structure. The proposed strategy relies on acquiring a pre-treatment 3D breath-hold scan, extracting a 3D target template and performing template matching between this 3D template and pairs of orthogonal 2D cine-MRI planes intersecting the target motion path. For a 60 s free-breathing series of orthogonal cine-MRI planes, we demonstrate that the method was capable of accurately tracking the respiration related 3D motion of the left kidney. Quantitative evaluation of the method using a dataset designed for this purpose revealed a translational error of 1.15 mm for a translation of 39.9 mm. We have demonstrated how interleaved acquired, orthogonal cine-MRI planes can be used for online tracking of soft-tissue target volumes.
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.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, University College London, Copenhagen University Hospital
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Pages: 1288-1291
Publication date: 2013
A Feasible Real-time Multiplane MRI-LINAC Guidance Strategy

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of Sydney, Copenhagen University Hospital
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Scopus rating (2015): SJR 2.333 SNIP 1.756 CiteScore 3.83
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Scopus rating (2009): SJR 2.286 SNIP 1.852
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Scopus rating (2008): SJR 2.381 SNIP 1.695
Anatomical Connectivity Mapping – Measuring connectivity changes in Multiple Sclerosis

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Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Danish Multiple Sclerosis Research Center, Danish Research Centre for Magnetic Resonance, University of Manchester
Authors: Lyksborg, M. (Intern), Larsen, R. (Intern), Sørensen, P. S. (Ekstern), Blinkenberg, M. (Ekstern), Dogonowski, A. (Ekstern), Garde, E. (Ekstern), Parker, G. J. M. (Ekstern), Siebner, H. R. (Ekstern), Dyrby, T. (Ekstern)
Number of pages: 1
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Classification of Polarimetric SAR Data Using Dictionary Learning
This contribution deals with classification of multilook fully polarimetric synthetic aperture radar (SAR) data by learning a dictionary of crop types present in the Foulum test site. The Foulum test site contains a large number of agricultural fields, as well as lakes, forests, natural vegetation, grasslands and urban areas, which make it ideally suited for evaluation of classification algorithms.

Dictionary learning centers around building a collection of image patches typical for the classification problem at hand. This requires initial manual labeling of the classes present in the data and is thus a method for supervised classification. Sparse coding of these image patches aims to maintain a proficient number of typical patches and associated labels. Data is consecutively classified by a nearest neighbor search of the dictionary elements and labeled with probabilities of each class.

Each dictionary element consists of one or more features, such as spectral measurements, in a neighborhood around each pixel. For polarimetric SAR data these features are the elements of the complex covariance matrix for each pixel. We quantitatively compare the effect of using different representations of the covariance matrix as the dictionary element features. Furthermore, we compare the method of dictionary learning, in the context of classifying polarimetric SAR data, with standard classification methods based on single-pixel measurements.

General information
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Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, National Space Institute, Geodesy
Authors: Vestergaard, J. S. (Intern), Nielsen, A. A. (Intern), Dahl, A. L. (Intern), Larsen, R. (Intern)
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Publication date: 2012
Correcting geometric distortions of Echo Planar Imaging using demons and reversed phase encoding
Demons Registration of CT Volume and CBCT Projections for Adaptive Radiotherapy: Avoiding CBCT Reconstruction

Purpose/Objective: In adaptive radiotherapy, the dose plan is adapted throughout the fractionation schedule to accommodate for anatomical changes. This can be achieved by deformable image registration of the planning PET-CT scan with segmented tumor and organs to daily cone beam CT (CBCT) scans. CBCT scans, are typically reconstructed using the filtered back-projection algorithm, which introduces significant artefacts, causing deteriorated image quality and registration results. We study the feasibility of performing demons registration without tomographic reconstruction of the CBCT projections.

Materials and Methods: We demonstrate demons registration [1,2] of a CT volume and CBCT projections of the same subject. For simplicity, instead of measured projections, we used synthetic projections of the CT deformed by a known deformation. A volume from [3] was used. The iterative registration is performed by repeating steps 1-4: 1. Simulate CBCT projections of deformed planning CT. 2. Back-project difference between simulated and measured projections. 3. Perform demons update based on back-projected difference. 4. Apply deformation to the planning CT. We used an additive demons update schemes with adaptive fluidity (smoothing kernel width). For forward/back-projection, the separable footprints algorithm with trapezoid functions was applied. The similarity between the simulated and measured projections was measured as the SSD.

Results: The figure shows a slice of; the CT volume (reference), the CT deformed by the known deformation (target), the relative Euclidean error of the true and estimated deformation fields, and the CT volume registered to the projections of the deformed CT. Interestingly, the deformation was accurately estimated from only 24 projections. The MSE between the target and registered image was 1.4·10^{-3} HU^2. The mean absolute difference between the Jacobian determinant of the true and estimated deformation field was 4.0·10^{-4}. 4. Time consumption was 11 min. using 8 2.3 GHz AMD Opteron cores.

Conclusions: In this feasibility study, using a known deformation and synthetic noise-less projection data, it was possible to estimate the deformation with good accuracy. For real projection data it might be necessary to use the mutual information similarity measure. Using few projections, daily dose burden could be decreased, or photon fluence for each projection increased. Time consumption was low compared to the alternative scheme of iterative reconstruction followed by registration, but can be reduced by further code parallelisation.
Does the Progress in Radiation Therapy Make Higher Demand to Interobserver Variability Correction? A Case Study of IMRT and Volumetric Arc Therapy

**General information**

**State:** Published
**Organisations:** Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Copenhagen University Hospital
**Authors:** Hollensen, C. (Intern), Persson, G. (Ekstern), Højgaard, L. (Ekstern), Specht, L. (Forskerdatabase), Larsen, R. (Intern)
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**Publication date:** 2012
**Conference:** American Society for Radiation Oncology 54th Annual Meeting, ASTRO's 54th Annual Meeting, Boston, MA, United States, 28/10/2012 - 28/10/2012
Purpose/Objective: Gross tumour volume (GTV) delineation is central for radiotherapy planning. It provides the basis of the clinical target volume and finally the planning target volume (PTV) which is used for dose optimization. GTV delineations are prone to intermethod and interobserver variation. In clinical studies this variation is commonly represented...
by geometrical volume comparison measures (GVCMs) as volume assessment, centre of mass and overlap. The correlation between these measures and the radiotherapy plan are however unclear. The aim of the present study is to investigate the correlation between GVCMs and the radiotherapy plans of patients with peripheral lung tumours.

Materials and Methods: Peripheral lung tumours of 10 patients referred for stereotactic body radiotherapy in 2008 were delineated by 3 radiologists and 3 oncologists. From these GTV delineations 6 different radiotherapy plans with RapidArc© were created for each patient using the same procedure for creation of PTV and dose optimisation. For each patient the volume receiving 90 % of the prescribed dose (V90) and the minimum dose that 90 % of the volume receives (D90) was extracted for the 6 delineations on each of radiotherapy plans. GVCMs as Dice overlap coefficient, mismatch, volume difference, center of mass distance, and Haussdorff distance were extracted between each pair of the delineations of GTV for each patient. Mismatch was defined as the volume of a GTV delineation outside the GTV delineation used to create the PTV divided volume of the GTV used to create the PTV. The Pearson correlation between the GVCMs and their corresponding difference in V90 and D90 was calculated and their statistical difference from zero and each other was tested with a t-test with a p-value of 0.05.

Results: The V90 and D90 were extracted for the 6 different PTVs on the 60 radiotherapy plans. The standard deviation for V90 and D90 were 5.5 % of the volume and 4.1 Gy respectively. The standard deviation in one image plane of one patient can be seen in the figure.

Figure: Standard deviation of the different radiotherapy plans in one plane for one patient. GTV contours in white. 150 estimations of the difference between the volumes were calculated for each of the GVCMs. The correlation results can be seen in the table.

Table: Correlation coefficients

<table>
<thead>
<tr>
<th></th>
<th>Correlation of V90</th>
<th>Correlation of D90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dice Coefficient</td>
<td>0.44 ± 0.10</td>
<td>0.43 ± 0.10</td>
</tr>
<tr>
<td>Mismatch</td>
<td>0.82 ± 0.03</td>
<td>0.71 ± 0.05</td>
</tr>
<tr>
<td>Volume difference</td>
<td>0.37 ± 0.10</td>
<td>0.32 ± 0.10</td>
</tr>
<tr>
<td>Center of mass</td>
<td>0.37 ± 0.09</td>
<td>0.49 ± 0.08</td>
</tr>
<tr>
<td>Hausdorff distance</td>
<td>0.37 ± 0.10</td>
<td>0.37 ± 0.10</td>
</tr>
</tbody>
</table>

All the correlation coefficients were found significantly different from 0. The correlation coefficient for mismatch was significantly different from all the other GVCMs for both V90 and D90. The correlation coefficient for center of mass was significantly different from the volume difference for D90.

Conclusions: Mismatch between GTVs is significantly more correlated with V90 and D90 than other GVCMs. Mismatch between GTVs could be used as an indicator for difference in V90 and D90 of their corresponding radiotherapy plans.

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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.

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Large scale tracking of stem cells using sparse coding and coupled graphs

Stem cell tracking is an inherently large scale problem. The challenge is to identify and track hundreds or thousands of cells over a time period of several weeks. This requires robust methods that can leverage the knowledge of specialists on the field. The tracking pipeline presented here consists of a dictionary learning method for segmentation of phase contrast microscopy images. Linking of the cells between two images is solved by a graph formulation of the tracking problem.

Lung Tumor Segmentation Using Electric Flow Lines for Graph Cuts

Lung cancer is the most common cause of cancer-related death. A common treatment is radiotherapy where the lung tumors are irradiated with ionizing radiation. The treatment is typically fractionated, i.e. spread out over time, allowing healthy tissue to recover between treatments and allowing tumor cells to be hit in their most sensitive phase. Changes in tumors over the course of treatment allows for an adaptation of the radiotherapy plan based on 3D computer tomography imaging. This paper introduces a method for segmentation of lung tumors on consecutive computed tomography images. These images are normally only used for correction of movements. The method uses graphs based on electric flow lines. The method offers several advantages when trying to replicate manual segmentations. The method gave a dice coefficient of 0.85 and performed better than level set methods and deformable registration.
Monitoring structure development in milk acidification using diffuse reflectance profiles

The structure of dairy products is important for the consumer, and milk acidification plays a central role for structural development. To ensure the best possible consumer experience, it is important that a product's structural properties are stable. Therefore process and quality control tools are needed so that the production can be carried out consistently, regardless of day-to-day variations in the raw materials.

Casein micelles aggregate during milk acidification, which leads to formation of a gel network. This change of structure is important for the development of a range of dairy products. It is therefore essential to monitor these structural changes and a variety of methods have been proposed to continuously follow this coagulation of milk [1]. Especially non-invasive methods for in situ production line application have been of interest.

We propose a method for analyzing structural changes in milk based on hyper-spectral light scattering. Our approach is motivated by Carstensen and Møller [2]. They demonstrated the correlation between diffuse reflectance profiles and rheology of a milk sample during acidification. In this work we employ a super-continuum laser light source coupled with an acousto-optical tuneable filter to illuminate the sample. The generated beam is spectrally narrow and can be tuned in the spectral range from 450-1050 nm. This system is described in detail in [3]. It is a research platform, which is constantly developed and adjusted according to research needs. Besides providing a non-invasive method, the system also has potential as a design platform for creating specialized and cost-efficient vision systems.

Our preliminary results are highly encouraging and show a clear relation between rheology and diffuse reflectance. A factorial experiment studying the effects of the content of fat, protein, and temperature in the acidification process is conducted. The purpose of the experiment is to investigate how the change of these parameters affects the diffuse reflectance properties as well as to demonstrate the relation between the optical parameters and structure formation in milk acidification. These measurements are compared to conventional methods such as pH, oscillatory rheology, confocal laser scanning microscopy, and sensory data.

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Motion Tracking for Medical Imaging: A Non-Visible Structured Light Tracking Approach

We present a system for head motion tracking in 3D brain imaging. The system is based on facial surface reconstruction and tracking using a structured light (SL) scanning principle. The system is designed to fit into narrow 3D medical scanner geometries limiting the field of view. It is tested in a clinical setting on the high resolution research tomograph (HRRT), Siemens PET scanner with a head phantom and volunteers. The SL system is compared to a commercial optical tracking system, the Polaris Vicra system, from NDI based on translatory and rotary ground truth motions of the head phantom. The accuracy of the systems was similar, with root-mean-square (RMS) errors of 0.09 ° for 20 ° axial rotations, and RMS errors of 0.24 mm for 25 mm translations. Tests were made using 1) a light emitting diode (LED) based miniaturized video projector, the Pico projector from Texas Instruments, and 2) a customized version of this projector replacing a visible light LED with a 850 nm near infrared LED. The latter system does not provide additional discomfort by visible light projection into the patient's eyes. The main advantage over existing head motion tracking devices, including the Polaris Vicra
system, is that it is not necessary to place markers on the patient. This provides a simpler workflow and eliminates uncertainties related to marker attachment and stability. We show proof of concept of a marker less tracking system especially designed for clinical use with promising results.

**General information**
State: Published
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BFI (2015): BFI-level 2
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Scopus rating (2014): SJR 1.407 SNIP 2.756 CiteScore 4.66
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Scopus rating (2012): SJR 1.545 SNIP 2.794 CiteScore 4.94
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Scopus rating (2010): SJR 1.343 SNIP 2.619
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Scopus rating (2008): SJR 1.404 SNIP 2.906
Scopus rating (2007): SJR 1.627 SNIP 3.948
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Scopus rating (2006): SJR 1.914 SNIP 3.337
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Scopus rating (2005): SJR 1.796 SNIP 3.754
Scopus rating (2004): SJR 1.632 SNIP 3.777
Web of Science (2004): Indexed yes
Non-invasive Estimation of Metabolic Uptake Rate of Glucose using F18-FDG PET and Linear Transformation of Outputs

For quantitative analysis and kinetic modeling of dynamic PET-data an input function is needed. Normally this is obtained by arterial blood sampling, potentially an unpleasant experience for the patient and laborious for the staff. Aim: To validate methods for determination of the metabolic uptake rate (Km) of glucose from dynamic FDG-PET scans using Image Derived Input Functions (IDIF) without blood sampling. Method: We performed 24 dynamic FDG-PET scans of the thigh of 14 healthy young male volunteers during a hyperinsulinemic isoglycemic clamp. Ten of the subjects were scanned twice 11 weeks apart and all with concurrent Arterial Blood Sampling (ABS). We proceeded to evaluate different earlier proposed methods as well as several new ones based on Archetypal Analysis for generating IDIFs. Comparison of the methods was based on the sets of Km-values generated for each scan from Patlak plots based on one common tissue curve against all the IDIFs. When compared to ABS Km values, an underestimation was found for all methods. Using ordinary least squares estimation on the ABS Km values vs. the IDIF Km a calibration factor and term was identified for each method and used for transformation. The Mean Squared Error (MSE) was determined for the different methods before transformation, and estimated by N-fold cross validation and 632+ bootstrapping after transformation. Further, since ordinary least squares is an unbiased estimator we could use the estimated MSE to determine the standard deviation of the different unbiased methods after transformation using the relation MSE(θ) = variance(θ)+bias(θ)^2.

Results: All methods performed poorly before transformation, except one described by Backes et al.. After transformation all methods yields unbiased Km based on the IDIF alone but have different standard deviations with the best method-Parker and Feng- at 0.0030 i. e. around 10 %. Conclusion: Based on this study, we can estimate the metabolic uptake rate of glucose with good accuracy and precision in similar future studies without blood sampling. Given the high variance of the femoral artery diameter in the material, the method should also be applicable to women and people of other ages, but used with caution in the elderly due to variance in intramuscular adipose distribution. If only Km and no other kinetic parameters are needed, the described method with transformation of the results based on ordinary least squares, gives unbiased low variance results without arterial blood sampling and it has the potential for use in other regions of the body.

General information
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Pipeline for Tracking Neural Progenitor Cells
Automated methods for neural stem cell lineage construction become increasingly important due to the large amount of data produced from time lapse imagery of in vitro cell growth experiments. Segmentation algorithms with the ability to adapt to the problem at hand and robust tracking methods play a key role in constructing these lineages. We present here a tracking pipeline based on learning a dictionary of discriminative image patches for segmentation and a graph formulation of the cell matching problem incorporating topology changes and acknowledging the fact that segmentation errors do occur. A matched filter for detection of mitotic candidates is constructed to ensure that cell division is only allowed in the model when relevant. Potentially the combination of these robust methods can simplify the initiation of cell
Planning and Evaluation of Radio-Therapeutic Treatment of Head-and-Neck Cancer Using PET/CT scanning

Radiation therapy relies in great extent on delineations of tumour and organs on medical images. These delineations are essential for the entire treatment. Unfortunately manual delineations are both prone to variation. At the same time the manual delineation process is time-consuming. This thesis represent a work within the automatic definition of organs and tumours. The thesis includes a summary of the prior methods employed for automatic segmentation and 3 articles describing segmentation algorithms of different areas of application for radiation therapy. Variation within and between manual and automatic segmentation methods is documented in the thesis. The last article of the thesis analyses treatment outcome difference due to manual delineation variation.
training data after which it is evaluated on previously unseen test data. The multi modal features investigated are 3 structural MRI modalities, the diffusion MRI measures of Fractional Anisotropy (FA), Mean Diffusivity (MD) and several spatial features. Results show a benefit from the inclusion of diffusion primarily to the most difficult cases. Results show that combining probabilistic K-Nearest Neighbour with a Markov Random Field formulation leads to a slight improvement of segmentations.

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Spatially varying Riemannian elasticity regularization: Application to thoracic CT registration in image-guided radiotherapy
For deformable registration of computed tomography (CT) scans in image guided radiation therapy (IGRT) we apply Riemannian elasticity regularization. We explore the use of spatially varying elasticity parameters to encourage bone rigidity and local tissue volume change only in the gross tumor volume (GTV) and the lungs. We evaluate the method on the point-validated 4DCT breathing thorax POPI-model and demonstrate its use and properties in registration of pre- and post-chemo CT scans for contour propagation in a Hodgkin lymphoma (HL) case showing significant tumor shrinkage. For the POPI-model we achieved a total mean target registration error (TRE) of 0.92 ± 0.49 mm. Using spatially varying regularization for the HL case, deformation was limited to the GTV and lungs.

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Statistical Surface Recovery: A Study on Ear Canals
We present a method for surface recovery in partial surface scans based on a statistical model. The framework is based on multivariate point prediction, where the distribution of the points are learned from an annotated data set. The training set consist of surfaces with dense correspondence that are Procrustes aligned. The average shape and point covariances can be estimated from this set. It is shown how missing data in a new given shape can be predicted using the learned statistics. The method is evaluated on a data set of 29 scans of ear canal impressions. By using a leave-one-out approach we reconstruct every scan and compute the point-wise prediction error. The evaluation is done for every point on the surface and for varying hole sizes. Compared to state-of-the art surface reconstruction algorithm, the presented methods gives very good prediction results.

General information
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Testosterone therapy decreases subcutaneous fat and adiponectin in aging men

OBJECTIVE: Testosterone therapy increases lean body mass and decreases total fat mass in aging men with low normal testosterone levels. The major challenge is, however, to determine whether the metabolic consequences of testosterone therapy are overall positive. We have previously reported that 6-month testosterone therapy did not improve insulin sensitivity. We investigated the effect of testosterone therapy on regional body fat distribution and on the levels of the insulin-sensitizing adipokine, adiponectin, in aging men with low normal bioavailable testosterone levels. DESIGN: A randomized, double-blinded, placebo-controlled study on 6-month testosterone treatment (gel) in 38 men, aged 60–78 years, with bioavailable testosterone 94 cm. METHODS: Central fat mass (CFM) and lower extremity fat mass (LEFM) were measured by dual X-ray absorptiometry. Subcutaneous abdominal adipose tissue (SAT), visceral adipose tissue (VAT), and thigh subcutaneous fat area (TFA) were measured by magnetic resonance imaging. Adiponectin levels were measured using an in-house immunofluorometric assay. Coefficients (b) represent the placebo-controlled mean effect of intervention. RESULTS: LEFM was decreased (b=−0.47 kg, P=0.07) while CFM did not change significantly (b=−0.66 kg, P=0.10) during testosterone therapy. SAT (b=−3.0%, P=0.018) and TFA (b=−3.0%, P

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Scopus rating (2015): SJR 1.641 SNIP 1.521 CiteScore 4.06
Web of Science (2015): Indexed yes
We present a complete system for motion correction in high resolution brain positron emission tomography (PET) imaging. It is based on a compact structured light scanner mounted above the patient tunnel of the Siemens High Resolution Research Tomograph PET brain scanner. The structured light system is equipped with a near infrared diode and uses phase-shift interferometry to compute 3D representations of the forehead of the patient. These 3D point clouds are progressively aligned to a reference surface and 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 rst 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 focus the PET reconstructions. The system is near ready for clinical testing.
A Deformable Model for Bringing Particles in Focus

We provide a deformable model for particle analysis. We investigate particle images from a backlit microscope system where particles suffer from out-of-focus blur. The blur is a result of particles being in front or behind the focus plane, and the out-of-focus gives a bias towards overestimating the particle size. This can be handled by only including the particles in focus, but most of the depicted particles will be left out of the analysis, which weakens the statistical estimate of the monitored process. We propose a new method for particle analysis. The model incorporates particle shape, size and intensity, which enables an estimation of the out-of-focus blur of the particle. Using the particle model parameters in a regression model we are able to infer 3D information about individual particles. Based on the defocus information we are able to infer the true size and shape of the particles. We demonstrate the capabilities of our model on both real and simulated data, and our approach shows promising results for a reliable particle analysis. The potential is more process information obtained over shorter sampling time.

Analysis of Pregerminated Barley Using Hyperspectral Image Analysis

Pregermination is one of many serious degradations to barley when used for malting. A pregerminated barley kernel can under certain conditions not regerminate and is reduced to animal feed of lower quality. Identifying pregermination at an early stage is therefore essential in order to segregate the barley kernels into low or high quality. Current standard methods to quantify pregerminated barley include visual approaches, e.g. to identify the root sprout, or using an embryo staining method, which use a time-consuming procedure. We present an approach using a near-infrared (NIR) hyperspectral imaging system in a mathematical modeling framework to identify pregerminated barley at an early stage of approximately 12 h of pregermination. Our model only assigns pregermination as the cause for a single kernel's lack of
germination and is unable to identify dormancy, kernel damage etc. The analysis is based on more than 750 Rosalina barley kernels being pregerminated at 8 different durations between 0 and 60 h based on the BRF method. Regerminating the kernels reveals a grouping of the pregerminated kernels into three categories: normal, delayed and limited germination. Our model employs a supervised classification framework based on a set of extracted features insensitive to the kernel orientation. An out-of-sample classification error of 32% (CI95%: 29–35%) is obtained for single kernels when grouped into the three categories, and an error of 3% (CI95%: 0–15%) is achieved on a bulk kernel level. The model provides class probabilities for each kernel, which can assist in achieving homogeneous germination profiles. This research can further be developed to establish an automated and faster procedure as an alternative to the standard procedures for pregerminated barley.

General information
State: Published
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.384 SNIP 1.446 CiteScore 3.1
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.408 SNIP 1.392
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.317 SNIP 1.303
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.361 SNIP 1.324
A Spiral And Discipline-Oriented Curriculum In Medical Imaging

This contribution describes and evaluates an experimental combination of a spiral and discipline-oriented curriculum implemented in the bachelor's and master's program in Medicine and Technology. The implementation in the master's program is in the form of a study line in Medical Imaging and Radiation Physics containing three disciplines: Imaging modalities, Radiation therapy and Image processing. The two imaging courses in the bachelor's program and the first imaging course in the master's program follow a spiral curriculum in which most disciplines are encountered in all courses, but in a gradually more advanced manner. The remaining courses in the master's program follow a discipline-oriented curriculum. From a practical point of view, the spiral course portfolio works well in an undergraduate environment, where the courses involved are to be taken by all students and in the order planned. However, in the master's program, such a tight schedule is impractical since students are likely to seek specialization. From a pedagogical point of view, the spiral curriculum is advantageous to use in the initial semesters where the teaching can be conducted so that the students can build on their intuitive understanding of the subject. The program was evaluated in terms of the progression in scientific demands in exam from course to course and in terms of the pattern of course selection by the students. The analysis was based on 96 students. The pattern of course selection was found to follow the intentions of the program, thus demonstrating high fulfillment of the learning outcomes.

General information
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Automatic Segmentation of Abdominal Adipose Tissue in MRI
This paper presents a method for automatically segmenting abdominal adipose tissue from 3-dimensional magnetic resonance images. We distinguish between three types of adipose tissue; visceral, deep subcutaneous and superficial subcutaneous. Images are pre-processed to remove the bias field effect of intensity in-homogeneities. This effect is estimated by a thin plate spline extended to fit two classes of automatically sampled intensity points in 3D. Adipose tissue pixels are labelled with fuzzy c-means clustering and locally determined thresholds. The visceral and subcutaneous adipose tissue are separated using deformable models, incorporating information from the clustering. The subcutaneous adipose tissue is subdivided into a deep and superficial part by means of dynamic programming applied to a spatial transformation of the image data. Regression analysis shows good correspondences between our results and total abdominal adipose tissue percentages assessed by dual-emission X-ray absorptiometry ($R^2 = 0.86$).

General information
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Organisations: Department of Informatics and Mathematical Modeling, DTU Data Analysis, Image Analysis and Computer Graphics, Steno Diabetes Centre
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Pages: 501-511
Publication date: 2011

Classification Methods for CT-Scanned Carcass Midsections: A Study of Noise Stability
Computed tomography (CT) has successfully been applied in medical environments for decades. In recent years CT has also made its entry to the industrial environments, including the slaughterhouses. In this paper we investigate classification methods for an online CT system, in order to assist in the segmentation of the outer fat layer in the mid- section of CT-scanned pig carcasses. Prior information about the carcass composition can potentially be applied for a fully automated solution, in order to optimize the slaughter line. The methods comprise Markov Random Field and contextual Bayesian classification, and are adapted to use neighbourhood information in 2D and 3D. Artificial Poisson noise is added to the provided dataset to determine how well each of the methods handles noise. Good noise handling will allow lower dose scannings. The investigated methods did not perform better than the reference model in terms of classification, but the MRF segmentation showed promising results in a case with extreme simulated noise.

General information
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Number of pages: 98
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Publication date: 2011
Comparison of external motion tracking systems for PET list-mode reconstruction

The present improvement that we see in 3D medical scanner technology including increasing spatio-temporal resolution and increasing signal-to-noise ratio underlines the need for reliable motion correction. Many motion correction schemes assume that the motions are known [1-3]. However, a reliable markerless tracking system is not trivial to provide and to our knowledge not presently existent. The Polaris Vicra optical tracking system (Northern Digital Inc.) is generally used with PET brain imaging and has been demonstrated to work very well on phantoms [4]. However, it suffers from the necessary attachment of markers to the subject introducing image artifacts on human scans. We have previously designed a camera-based structured light (SL) system for 3D head tracking used with the high resolution research tomograph (HRRT, Siemens, Knoxville, USA) [5]. The system was modified to use invisible light and the accuracy was demonstrated similar to a commercial system [6]. Presently, we show the SL system integrated with the HRRT PET scanner ready for PET motion correction. We show a comparison study with the Polaris Vicra based on list-mode motion corrected [7].

Computed Tomography in the Modern Slaughterhouse

The Danish pig meat industry has been seeing a growing international competition in the past years. In the quest to maintain both competitive prices and high product standards in spite of the higher Danish factor costs, a substantial effort is being put into innovation, research and development of technology. Recently, the use of X-ray computed tomography (CT) coupled with methods from image analysis has been introduced as a powerful means to optimise production, by providing detailed information on the raw materials. This thesis covers two aspects of the application of CT in the modern abattoir. In the first aspect we use CT to analyse the biological diversity of carcass populations. The images form the basis for a data-driven tissue deformation model. The results provide valuable input to assist the development of an automated robotic tool for trimming the rind off pig backs. The second aspect concerns measurements of each single carcass, to improve the raw material utilisation by individually adapted processing. Measurements performed online in the abattoir demand fast, robust and cost-effective imaging. We propose a tomographic reconstruction algorithm, enabling a substantial reduction of the subject-specific X-ray data needed to produce high quality images for accurate measurements. This is very beneficial for the abattoirs, as a reduction in acquired data translates directly into higher speed and a lower cost. The thesis demonstrates the great potential of CT as a technology for improving the yield of the Danish pig meat industry. An introduction of efficient online CT will especially open a vast number of possibilities for optimising the production.
Contour Propagation With Riemannian Elasticity Regularization: Abstract

Purpose/Objective(s): Adaptive techniques allow for correction of spatial changes during the time course of the fractionated radiotherapy. Spatial changes include tumor shrinkage and weight loss, causing tissue deformation and residual positional errors even after translational and rotational image guided corrections. This study compares manual delineations in replanning CT scans of head-and-neck patients to automatic contour propagation using deformable registration with Riemannian regularization. The potential benefit of locally assigned regularization parameters according to tissue type is investigated.

Materials/Methods: Planning PET-CT scans plus 2 - 4 subsequent replanning CTs for five head-and-neck cancer patients were obtained. The Gross Tumor Volume (GTV) was manually delineated on the planning CT by an experienced clinician and manually propagated by pasting the set of contours from the planning CT onto the rescans and correcting to reflect actual anatomical changes. For deformable registration, a free-form, multi-level, B-spline deformation model with Riemannian elasticity, penalizing non-rigid local deformations, and volumetric changes, was used. Regularization parameters was defined on a voxel basis, according to segmentations of bone, soft tissues and GTVs, ensuring smooth, diffeomorphic registration, while sustaining bone rigidity and allowing for large volume changes of the GTV. For comparison both rigid registration and deform registration with globally defined Riemannian regularization parameters was performed. For each replanning scan, the volume of the manually delineated and automatically propagated GTV was determined and Dice’s coefficient was calculated between segmentations from the propagated contours and manual delineations. Results: The replanning segmentations showed substantial volume changes. The Dice coefficients indicate substantial improvement from rigid to deform registration with local regularization parameters. Conclusions: Deform contour propagation based entirely on the original delineation and tissue deformation in the time course between scans form a better starting point than rigid propagation. There was no significant difference of locally and globally defined regularization. The method used in the present study suggests that deformed contours need to be reviewed and corrected by an oncologist.
It seems that great shifts in how human beings use technology often create a push for changes to the way we divide work between human beings and technology. Chemical film has all but disappeared and almost everybody takes digital photos which they proceed to put online for easy sharing with friends and family. Together with a number of other trends which have contributed to the vast amount of online and locally stored digital photos, this has made automatic recognition of people in images an important research topic - in spite of the fact that recognition is one of the tasks generally left to human beings, since we excel at recognition. We believe that recognition of the style of a 3D object is something that is also likely to be increasingly useful in the foreseeable future. Optical scanning methodologies make the generation of 3D content more feasible than previously, and it is easy to envision digital artists wanting to compile content for a 3D scene or composite object being in need of a method for searching for an object not just of a specific function but also a specific style. The scope broadens further if we look beyond man made objects. It seems clear that, say, the various limbs of a specific human being have some commonality that separate them from those of another person. Thus, one could argue that an individual represents a style. Style in the context of biological variation is something that we explore in the work
presented here. Specifically, we investigate whether we can define a style class for the teeth of a person. Unfortunately, style is subtle and we do not hope to be able to automatically extract a description of style from 3D objects. Furthermore, we avoid using explicit ways of describing style. Recognizing the style of an object based on some textual or otherwise encoded information might be a feasible approach in some cases such as, for instance, recognizing to which order a given classical greek column belongs. But, relying on explicit information about a given style would require us either to solve the above problem of automatically extracting style information from shapes or to rely on human beings to encode style - a task that we believe would be both tedious and difficult. Instead, we rely on examples in the work presented here. This requires that we have example (training) objects for each style. It also requires that we have an orthogonal class of functions, since, as we discuss below, the function of the object (what it is) clearly also has a profound impact on shape. Thus, our work can be summed up as example based classification of digital 3D shapes in both style and function categories.

General information
State: Published
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Differential Nongenetic Impact of Birth Weight Versus Third-Trimester Growth Velocity on Glucose Metabolism and Magnetic Resonance Imaging Abdominal Obesity in Young Healthy Twins
Context: Low birth weight is associated with type 2 diabetes, which to some extent may be mediated via abdominal adiposity and insulin resistance. Fetal growth velocity is high during the third trimester, constituting a potential critical window for organ programming. Intra-pair differences among monozygotic twins are instrumental in determining nongenetic associations between early environment and adult metabolic phenotype. Objective: Our objective was to investigate the relationship between size at birth and third-trimester growth velocity on adult body composition and glucose metabolism using intra-pair differences in young healthy twins. Methods: Fifty-eight healthy twins (42 monozygotic/16 dizygotic) aged 18-24 yr participated. Insulin sensitivity was assessed using hyperinsulinemic-euglycemic clamps. Whole-body fat was assessed by dual-energy x-ray absorptiometry scan, whereas abdominal visceral and sc fat (L1-L4) were assessed by magnetic resonance imaging. Third-trimester growth velocity was determined by repeated ultrasound examinations. Results: Size at birth was nongenetically inversely associated with adult visceral and sc fat accumulation but unrelated to adult insulin action. In contrast, fetal growth velocity during third trimester was not associated with adult visceral or sc fat accumulation. Interestingly, third-trimester growth was associated with insulin action in a paradoxical inverse manner. Conclusions: Abdominal adiposity including accumulation of both sc and visceral fat may constitute primary nongenetic factors associated with low birth weight and reduced fetal growth before the third trimester. Reduced fetal growth during vs. before the third trimester may define distinct adult trajectories of metabolic and anthropometric characteristics influencing risk of developing type 2 diabetes. (J Clin Endocrinol Metab 96: 2835-2843, 2011)

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Organisations: DTU Data Analysis, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Steno Diabetes Centre, Novo Nordisk A/S, Copenhagen University Hospital, University of Copenhagen
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Efficient Hyperelastic Regularization for Registration

For most image registration problems a smooth one-to-one mapping is desirable, a diffeomorphism. This can be obtained using priors such as volume preservation, certain kinds of elasticity or both. The key principle is to regularize the strain of the deformation which can be done through penalization of the eigen values of the stress tensor. We present a computational framework for regularization of image registration for isotropic hyper elasticity. We formulate an efficient and parallel scheme for computing the principal stain based for a given parameterization by decomposing the left Cauchy-Green strain tensor and deriving analytical derivatives of the principal stretches as a function of the deformation, guaranteeing a diffeomorphism in every evaluation point. Hyper elasticity allows us to handle large deformation without re-meshing. The method is general and allows for the well-known hyper elastic priors such as the Saint Vernant Kirchoff model, the Ogden material model or Riemanian elasticity. We exemplify the approach through synthetic registration and special tests as well as registration of different modalities; 2D cardiac MRI and 3D surfaces of the human ear. The artificial examples illustrate the degree of deformation the formulation can handle numerically. Numerically the computational...
Elastic Appearance Models

This paper presents a fusion of the active appearance model (AAM) and the Riemannian elasticity framework which yields a non-linear shape model and a linear texture model – the active elastic appearance model (EAM). The non-linear elasticity shape model is more flexible than the usual linear subspace model, and it is therefore able to capture more complex shape variations. Local rotation and translation invariances are the primary explanation for the additional flexibility. In addition, we introduce global scale invariance into the Riemannian elasticity framework which together with the local translation and rotation invariances eliminate the need for separate pose estimation. The new approach was tested against AAM in three experiments; face labeling, face labeling with poor initialization and corpus callosum segmentation. In all the examples the EAM performed significantly better than AAM. Our Matlab implementation can be downloaded through svn from https://svn.imm.dtu.dk/AAMLab/svn/AAMLab/trunk/
**Example based style classification**

We address the problem of analysis of families of shapes which can be classified according to two categories: the main one corresponding usually to the coarse shape which we call the function and the more subtle one which we call the style. The style and the function both contribute to the overall shape which makes the general analysis and retrieval of such shapes more challenging. Also there is no single way of defining the style as this depends much on the context of the family of shapes used for the analysis. That is why the definition needs to be given through the examples. The straightforward way of finding the shape descriptors 'responsible' for a given category would be to use well known statistical methods and find through them such descriptors with which we are able to classify shapes according to a given category. When a function is dominating this approach might not suffice - we might be unable to find a set descriptors which are independent of a given function. We show how to decouple the effect of the style from that of the function by considering the shapes of the same function but different styles. We also propose a metric coanalysis approach: if two styles are similar this similarity should be reflected across different functions. We show the usability of our methods first on the example of a number of chess sets which our method helps sort. Next, we investigate the problem of finding a replacement for a missing tooth given a database of teeth.

**Geometrical characterization of interconnected phase networks in three dimensions**

In electrochemical devices such as fuel cells or batteries the microstructure is a determining factor for the performance of the device. To be able to optimize the microstructure it is important to be able to quantitatively measure key structural parameters, such that systematic studies can be made. We present several general methods for quantitative characterization of network structures without prior assumptions of shape or application. The characterization is performed by extracting distributions of values rather than single value descriptions, thus allowing more detailed comparisons between samples to be made. The methods characterize tortuosity, path diameters, the novel dead ends property and a particle shape independent alternative to a particle size distribution. The parameters are calculated by the computation of arrival time maps by the fast marching method. The methods are applied to the analysis of each of the three phases in a solid oxide fuel cell sample.
Geometric calibration between PET scanner and structured light scanner

Head movements degrade the image quality of high resolution Positron Emission Tomography (PET) brain studies through blurring and artifacts. Many image reconstruction methods allows for motion correction if the head position is tracked continuously during the study. Our method for motion tracking is a structured light scanner placed just above the patient tunnel on the High Resolution Research Tomograph (HRRT, Siemens). It continuously registers point clouds of a part of the patient's face. The relative motion is estimated as the rigid transformation between frames. A geometric calibration between the HRRT scanner and the tracking system is needed in order to reposition the PET listmode data or image frames in the HRRT scanner coordinate system. This paper presents a method where obtained transmission scan
data is segmented in order to create a point cloud of the patient's head. The point clouds from both systems can then be aligned to each other using the Iterative Closest Point (ICP) algorithm.

**General information**

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**Hyperspectral Image Analysis of Food Quality**

Assessing the quality of food is a vital step in any food processing line to ensure the best food quality and maximum profit for the farmer and food manufacturer. Traditional quality evaluation methods are often destructive and labour-intensive procedures relying on wet chemistry or subjective human inspection. Near-infrared spectroscopy can address these issues by offering a fast and objective analysis of the food quality. A natural extension to these single spectrum NIR systems is to include image information such that each pixel holds a NIR spectrum. This augmented image information offers several extensions to the analysis of food quality. This dissertation is concerned with hyperspectral image analysis used to assess the quality of single grain kernels. The focus is to highlight the benefits and challenges of using hyperspectral imaging for food quality presented in two research directions. Initially, the visualisation and interpretation of hyperspectral images are discussed. A Bayesian based unmixing method is presented as a novel approach to decompose a hyperspectral image into interpretable components. Secondly, hyperspectral imaging is applied to a dedicated application of predicting the pre-germination degree in single barley kernels using a customised classification framework. Both contributions serve to illustrate the improvement of adding image information to NIR systems in food quality assessment applications.

**General information**

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**Organisations:** Cognitive Systems, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics  
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**Improved Nowcasting of Heavy Precipitation Using Satellite and Weather Radar Data**

**General information**
Improving image registration by correspondence interpolation

This paper presents how using a correspondence-based interpolation scheme for 3D image registration improves the registration accuracy. The interpolator takes into account correspondences across slices, which is an advantage, particularly when the volume has thick slices, and where anatomies lie non-parallel to the slice direction. We use our previously presented approach for correspondence-based interpolation and demonstrate results on two different datasets, brain and cardiac MRI. The results are evaluated (i) qualitatively by examination of gradient images and cardiac pig atlases and (ii) quantitatively by registering downsampled brain data using two different interpolators and subsequently applying the deformation fields to the original data. The results show that the interpolator provides better gradient images and a more sharp cardiac atlas. Moreover, it provides better deformation fields on downsampled data, increasing the registration accuracy of original data to 5.8% on average with respect to a standard interpolator.

In Depth Analysis of Food Structures: Hyperspectral Subsurface Laser Scattering

In this paper we describe a computer vision system based on SLS (Subsurface Laser Scattering) for industrial food inspection. To obtain high and uniform quality, in for example dairy products like yoghurt and cheese, it is important to monitor the change in size and shape of microscopic particles over time. In this paper we demonstrate the usefulness of our SLS system for characterizing food items. We use a laser source that can be tuned to any wavelength in the range of 455 nm - 1020 nm by applying an AOTF (Acousto-Optical Tunable Filter) to an optical beam generated by a SuperK (supercontinuum) laser system. In our experiments we show how the system can be used for discriminating dairy products with different structure and how the structural change of a foam can be monitored over time. Time stability of the system is essential for measurements over several hours, and we demonstrate the time stability by measuring the reflectance profile of an inorganic phantom. The SLS technique is a very promising technique for non-intrusive food inspection, especially for homogenous products where particle size and shape are important parameters.
Learning Dictionaries of Discriminative Image Patches

Remarkable results have been obtained using image models based on image patches, for example sparse generative models for image inpainting, noise reduction and superresolution, sparse texture segmentation or texton models. In this paper we propose a powerful and yet simple approach for segmentation using dictionaries of image patches with associated label data. The approach is based on ideas from sparse generative image models and texton based texture modeling. The intensity and label dictionaries are learned from training images with associated label information of (a subset) of the pixels based on a modified vector quantization approach. For new images the intensity dictionary is used to encode the image data and the label dictionary is used to build a segmentation of the image. We demonstrate the algorithm on composite and real texture images and show how successful training is possible even for noisy image and low-quality label training data. In our experimental evaluation we achieve state-of-the-art performance for segmentation.

Learning Histopathological Patterns

We propose a technique for analyzing images of immunohistochemically stained tissue samples for extracting features that correlate with patient disease. We address the problem of quantifying tumor tissue and segmenting and counting nuclei. Our method utilizes a flexible segmentation technique trained from representative image samples. Nuclei counting is based on a nucleus model that takes size, shape and nucleus probability into account. We obtain the probability of a nucleus from our segmentation procedure. Our method is experimentally validated on images stained with nuclear markers for the Estrogen Receptor (ER) and proliferation marker KI-67. In addition we qualitatively validate our method for
tumor tissue segmentation and we obtain state of the art results on cell nuclei separation.

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**Markerless 3D Head Tracking for Motion Correction in High Resolution PET Brain Imaging**
This thesis concerns application specific 3D head tracking. The purpose is to improve motion correction in position emission tomography (PET) brain imaging through development of markerless tracking. Currently, motion correction strategies are based on either the PET data itself or tracking devices relying on markers. Data-driven motion correction is problematic due to the physiological dynamics. Marker-based tracking is potentially unreliable, and it is extremely hard to validate when the tracking information is correct. The motion estimation is essential for proper motion correction of the PET images. Incorrect motion correction can in the worst cases result in wrong diagnosis or treatment. The evolution of a markerless custom-made structured light 3D surface tracking system is presented. The system is targeted at state-of-the-art high resolution dedicated brain PET scanners with a resolution of a few millimeters. State-of-the-art hardware and software solutions are integrated into an operational device. This novel system is tested against a commercial tracking system popular in PET brain imaging. Testing and demonstrations are carried out in clinical settings. A compact markerless tracking system was developed with an accuracy sufficient for PET imaging (<0.1 degrees and <0.3 mm). Furthermore, the first non-visible structured light system using Pico DLP technology was used. In a proof-of-principle study with two human PET scans, the system was demonstrated to improve PET image quality significantly. The results were similar to motion correction using an integrated commercial marker-based system. Furthermore, phantom studies were performed supporting the system’s abilities for PET motion correction.

**General information**
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**Noise estimation in PET images**
Project Supervision – An Engineering Approach

For more than twenty years, a group based supervision strategy has been used when supervising engineering bachelor- and master thesis students at our research group. In recent years, we have formalised the approach and used our industry experience to create a very successful framework for project supervision. This paper is a best practice guide aiming at research groups that would like to try to implement our supervision approach or parts of it. The approach is based on the belief that engineering students should be prepared for their new role as development engineers or PhD students as part of their master thesis writing. The supervision principles are: Ownership: The student should feel that their project is their own. Ideally, they should formulate the project themselves. Write early: We strongly encourage the students to write and generate figures and images already from the first week of the project period. Management: The student is considered project manager of his own project. The supervisor is a guide or coach (or a project owner) Plans: The student is asked to write a project plan during the first week of the project together with a risk-analysis. Group Meetings: A group of students and supervisors meet every week on a fixed weekday. In our team, it is normal that one supervisor supervises three to five projects simultaneously. The core of the supervision is the weekly meetings where the students present what they have been doing and what they plan to do. By default, all students are present at all meetings. Weekly meetings are scheduled to be at a specific day at a specific place for the entire process.

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Real Time Surface Registration for PET Motion Tracking

Head movement during high resolution Positron Emission Tomography brain studies causes blur and artifacts in the images. Therefore, attempts are being made to continuously monitor the pose of the head and correct for this movement. Specifically, our method uses a structured light scanner system to create point clouds representing parts of the patient's face. The movement is estimated by a rigid registration of the point clouds. The registration should be done using a robust algorithm that can handle partial overlap and ideally operate in real time. We present an optimized Iterative Closest Point algorithm that operates at 10 frames per second on partial human face surfaces. © 2011 Springer-Verlag.

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Organisations: DTU Data Analysis, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of Eastern Finland, Gjøvik University College
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Segmentation Using Symmetry Deviation: Abstract

Purpose: The manual delineation of gross tumour volume (GTV) for radiation therapy for head and neck cancer patients relies in some degree of pathological deviation from normal anatomical symmetry. The purpose of this study is to introduce a novel method for 3-dimensional determination of GTV and evaluate the method. The method uses deformable registration on computed tomography (CT) to find anatomical symmetry deviations of Head & Neck squamous cell carcinoma and combining it with positron emission tomography (PET) images. The method allows the use anatomical and symmetrical information of CT scans to improve automatic delineations. Materials: PET/CT scans from 30 patients were used for this study, 20 without cancer in hypopharyngeal volume and 10 with hypopharyngeal carcinoma. An head and neck atlas was created from the 20 normal patients. The atlas was created using affine and non-rigid registration of the CT-scans into a single atlas. Afterwards the standard deviation of anatomical symmetry for the 20 normal patients was evaluated using non-rigid registration and registered onto the atlas to create an atlas for normal anatomical symmetry deviation. The same non-rigid registration was used on the 10 hypopharyngeal cancer patients to find anatomical symmetry and evaluate it against the standard deviation of the normal patients to locate pathologic volumes. Combining the information with an absolute PET threshold of 3 Standard uptake value (SUV) a volume was automatically delineated.

Results: The anatomical and symmetrical atlas was constructed. The standard deviation of the anatomical symmetry, seen in figure for one patient along CT and PET, was extracted for normal patients and compared with the deviation from cancer patients giving a new way of determining cancer pathology location. Using the novel method an overlap concordance index and sensitivity of respectively 0.43±0.15 and 0.56±0.18 was acquired. It was compared to the concordance index of segmentation using absolute threshold of 3 SUV giving respectively 0.41±0.16 and 0.51±0.19 for concordance index and sensitivity yielding p-values of 0.33 and 0.01 for a paired t-test respectively.
Sparse principal component analysis in hyperspectral change detection

This contribution deals with change detection by means of sparse principal component analysis (PCA) of simple differences of calibrated, bi-temporal HyMap data. Results show that if we retain only 15 nonzero loadings (out of 126) in the sparse PCA the resulting change scores appear visually very similar although the loadings are very different from their usual non-sparse counterparts. The choice of three wavelength regions as being most important for change detection demonstrates the feature selection capability of sparse PCA.

General information
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Supercontinuum Light Sources for Hyperspectral Subsurface Laser Scattering: Applications for Food Inspection

A materials structural and chemical composition influences its optical scattering properties. In this paper we investigate the use of subsurface laser scattering (SLS) for inferring structural and chemical information of food products. We have constructed a computer vision system based on a supercontinuum laser light source and an Acousto-Optic Tunable Filter (AOTF) to provide a collimated light source, which can be tuned to any wavelength in the range from 480 to 900 nm. We present the newly developed hyperspectral vision system together with a proof-of-principle study of its ability to discriminate between dairy products with either similar chemical or structural composition. The combined vision system is a new way for industrial food inspection allowing non-intrusive online process inspection of parameters that is hard with existing technology.

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Temporal Volume of Lung Tumor during Treatment with Tomotherapy

General information
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Ultra Fast Optical Sectioning: Signal preserving filtering and surface reconstruction

In 3D surface scanning it is desirable to filter away bad data without altering the quality of the remaining good data. Filtering of raw scanner data before surface reconstruction can minimize the induced error and improve on the probability of reconstructing the true surface. If outliers consist of actual data such as hair, and not just evenly distributed noise, these outliers tend to err smoothing algorithms away from the wanted result. We present a novel algorithm based on a Markov Random Field that uses a distance constraint to robustly classify a 3D scan volume. Through this classification a signal preserving filtering of the data set is done. The remaining data are used for a smooth surface reconstruction creating very plausible surfaces. The data used in our work comes from a newly developed hand held 3D scanner. The scanner is an Ultra Fast Optical Sectioning scanner, which is able to extract high quality 3D surface points from 2D images recorded at over 3000 fps. The scanner has been developed for digital impression taking in the dental area. Our work relates to future in-ear scanning for fitting custom hearing aids without impression taking.

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Longitudinal MRI studies of brain morphometry

High resolution MR images acquired at multiple time points of the brain allow quantification of localized changes induced by external factors such as maturation, ageing or disease progression/recovery. High-dimensional warping of such MR images incorporates changes induced by external factors into the accompanying deformation field. Deformation fields from high dimensional warping founds tensor based morphometry (TBM), and provides unique opportunities to study human brain morphology and plasticity. In this thesis, specially adapted image processing streams utilizing several image registration techniques to characterize differences between brains, demonstrate the versatility and specificity of the employed voxel-wise morphometric methods. More specifically TBM is used to study neurodegenerative changes following severe traumatic brain injuries. Such injuries progress for months, perhaps even years postinjury. Little information is known about the spatial distribution and the clinical significance of this late atrophy. TBM revealed a large coherent cluster of significant atrophy consisting of the brain stem and cerebellar peduncles extending bilaterally through the thalamus, internal and external capsules, putamen, inferior and superior longitudinal fasciculus, corpus callosum and corona radiata. This indicates that the long-term atrophy is attributable to consequences of traumatic axonal injury. Despite progressive atrophy, remarkable clinical improvement occurred in most patients. The other study utilized TBM and voxel based morphometry (VBM) in two separate papers concerning antipsychotic-naive first episode schizophrenia. Volume reductions of hippocampal and caudate regions were found in patients compared to controls using VBM. Six months later, TBM revealed continued volume loss in striatum and hippocampus, despite treatment with quetiapine. The mechanisms underlying these progressive brain dynamics, specific antipsychotic compounds and clinical symptoms warrant further clarification.

General Information

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Quantitative data analysis methods for 3D microstructure characterization of Solid Oxide Cells

The performance of electrochemical ceramic devices such as solid oxide fuel and electrolyser cells depends on the distribution of constituent phases on the micro or nano scale, also known as the microstructure. The microstructure governs key properties such as ion, electron and gas transport through percolating networks and reaction rates at the triple phase boundaries. Quantitative analysis of microstructure is thus important both in research and development of optimal microstructure design and fabrication. Three dimensional microstructure characterization in particular holds great promise for gaining further fundamental understanding of how microstructure affects performance. In this work, methods for automatic 3D characterization of microstructure are studied: from the acquisition of 3D image data by focused ion beam tomography to the extraction of quantitative measures that characterize the microstructure. The methods are exemplified by the analysis of Ni-YSZ and LSC-CGO electrode samples. Automatic methods for preprocessing the raw 3D image data are developed. The preprocessing steps correct for errors introduced by the image acquisition by the focused ion beam serial sectioning. Alignment of the individual image slices is performed by automatic detection of fiducial marks. Uneven illumination is corrected by fitting hypersurfaces to the spatial intensity variation in the 3D image data. Routine use of quantitative three dimensional analysis of microstructure is generally restricted by the time consuming task of manually delineating structures within each image slice or the quality of manual and automatic segmentation schemes. To solve this, a framework for the automatic segmentation of 3D image data is developed. The technique is based on a level set method and uses numerical approximations to partial differential equations to evolve a 3D surface to capture the phase boundaries. Vector fields derived from the experimentally acquired data are used as the driving forces. The framework performs the segmentation in 3D rather than on a slice by slice basis. It naturally supplies sub-voxel accuracy of segmented surfaces and allows constraints on the surface curvature to enforce a smooth surface in the segmentation. A high accuracy method is developed for calculating two phase boundary surface areas and triple phase boundary length of triple phase systems. The calculations are based on sub-voxel accuracy segmentations of the constituent phases. The method performs a three phase polygonization of the interface boundaries which results in a non-manifold mesh of connected faces. The triple phase boundaries can be extracted from the mesh as connected curve loops without branches. The accuracy of the method is analyzed by calculations on geometrical primitives. A suite of methods is
developed for characterizing the shape and connectivity of phase networks. The methods utilize the fast marching method to compute distance maps and optimal paths in the microstructure network. The extracted measurements are suited for the quantitative comparison and evaluation of microstructures. The quantitative measures characterize properties of network path tortuosity, network thickness, transport path width and dead ends.

Active illumination and appearance model for face alignment

Illumination conditions have an explicit effect on the performance of face recognition systems. In particular, varying the illumination upon the face imposes such, complex effects that the identification often fails to provide a stable performance level. In this paper, we propose an approach, integrating face identity and illumination models in order to reach acceptable and stable face recognition rates. For this purpose, Active Appearance Model (AAM) and illumination model of faces are combined in order to obtain an illumination invariant face localization. The proposed method is an integrated Active Illumination and Appearance Model (AIA) which combines identity, illumination and shape components in a single model and allows us to control them, separately. One of the major advantage of the proposed AIA model is that efficient model fitting is achieved, whilst maintaining performance against illumination changes. In addition to model fitting, images illuminated from, different directions can easily be synthesized by changing the parameters related to illumination modes. The method provides a, practical approach, since only one image with, frontal illumination of each person for training, is sufficient. There is no need to build complex models for illumination. As a result, this paper has presented a simple and efficient method for face modeling and face alignment in order to increase the performance of face localization by means of the proposed illumination invariant AIA method for face alignment, such as the Active Appearance Models, invariant to changes in, illumination. From the experimental results, we showed that the proposed AIA model provides higher accuracy than classical Active Appearance Model for face alignment in a point-to-point error sense.
A framework for automatic segmentation in three dimensions of microstructural tomography data

Routine use of quantitative three dimensional analysis of material microstructure by in particular, focused ion beam (FIB) serial sectioning is generally restricted by the time consuming task of manually delineating structures within each image slice or the quality of manual and automatic segmentation schemes. We present here a framework for performing automatic segmentation of complex microstructures using a level set method. The technique is based on numerical approximations to partial differential equations to evolve a 3D surface to capture the phase boundaries. Vector fields derived from the experimentally acquired data are used as the driving forces. The framework performs the segmentation in 3D rather than on a slice by slice basis. It naturally supplies sub-voxel precision of segmented surfaces and allows constraints on the surface curvature to enforce a smooth surface in the segmentation. Two applications of the framework are illustrated using solid oxide cell materials as examples.
Anatomically Plausible Surface Alignment and Reconstruction

With the increasing clinical use of 3D surface scanners, there is a need for accurate and reliable algorithms that can produce anatomically plausible surfaces. In this paper, a combined method for surface alignment and reconstruction is proposed. It is based on an implicit surface representation combined with a Markov Random Field regularisation method. Conceptually, the method maintains an implicit ideal description of the sought surface. This implicit surface is iteratively updated by realigning the input point sets and Markov Random Field regularisation. The regularisation is based on a prior
energy that has earlier proved to be particularly well suited for human surface scans. The method has been tested on full cranial scans of ten test subjects and on several scans of the outer human ear.

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A statistical approach to motion compensated cone-beam
One of the problems arising in radiotherapy planning is the quality of CT planning data. In the following attention is giving to the cone-beam scanning geometry where reconstruction of a 3D volume based on 2D projections, using the classic Feldkamp-Davis-Kress (FDK) algorithm requires a large number of projections to be adequate. Since the patients are breathing freely during a scan, the number of projections with similar respiration may be to low. In the following we use an iterative reconstruction combined with the simultaneous estimation of the motion field, to improve reconstruction in these situations. Using a simulated dataset we demonstrate that this combination outperforms the FDK but due to ill possessedness of the motion estimation it is only on par with the sole iterative method.

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A Statistical Approach to Motion Compensated Cone Beam Reconstruction
One of the problems arising in radiotherapy planning is the quality of CT planning data. In the following attention is giving to the cone-beam scanning geometry where reconstruction of a 3D volume based on 2D projections, using the classic Feldkamp-Davis-Kress (FDK) algorithm requires a large number of projections to be adequate. Since the patients are breathing freely during a scan, the number of projections with similar respiration may be to low. In the following we use an iterative reconstruction combined with the simultaneous estimation of the motion field, to improve reconstruction in these situations. Using a simulated dataset we demonstrate that this combination outperforms the FDK but due to ill possessedness of the motion estimation it is only on par with the sole iterative method.

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
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A Unifying model of perfusion and motion applied to reconstruction of sparsely sampled free-breathing myocardial perfusion MRI

The clinical potential of dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) is currently limited by respiratory induced motion of the heart. This paper presents a unifying model of perfusion and motion in which respiratory motion becomes an integral part of myocardial perfusion quantification. Hence, the need for tedious manual motion correction prior to perfusion quantification is avoided. In addition, we demonstrate that the proposed framework facilitates the process of reconstructing DCEMRI from sparsely sampled data in the presence of respiratory motion. The paper focuses primarily on the underlying theory of the proposed framework, but shows in vivo results of respiratory motion correction and simulation results of reconstructing sparsely sampled data.

General information
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Automatic Thresholding for Frame-Repositioning Using External Tracking in PET Brain Imaging

Motion correction (MC) in positron emission tomography (PET) brain imaging become of higher importance with increasing scanner resolution. Several motion correction methods have been suggested and so far the Polaris Vicra tracking system has been the preferred one for motion registration. We present an automated algorithm for dividing PET acquisitions into subframes based on the registered head motion to correct for intra-frame motion with the frame repositioning MC method. The method is tested on real patient data (five 11C-SB studies and five 11C-PIB studies) and compared with an image based registration method (AIR). Quantitative evaluation was done using a correlation measure. The study shows that MC improves the correlation of the PET images and that AIR performed slightly better than the Polaris Vicra. We found significant intra-frame motion of 1-5 mm in 9 frames but the correlation was not significantly improved using intra-frame MC.

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Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Siemens Healthcare, Copenhagen University Hospital
**Auto-Segmentation of Head and Neck Cancer using Textural features**

**Purpose:** The conventional treatment for non-metastatic Head & Neck squamous cell carcinoma (HNSCC) is radiation therapy. Despite technological advances and improved efficacy radiation therapy still relies on manual delineation of gross tumour volume which is both time consuming and prone to inter- and intra-observer variability. Several automatic segmentation methods have been developed using positron emission tomography (PET) and/or computerised tomography (CT). The aim of the present study is to develop a model for 3-dimensional auto-segmentation, the level set method, to contour gross tumour volumes (GTV) in a training set of 20 HNSCC patients and evaluate its performance in an independent test set of 25 patients. Materials and Methods: 100 PET/CT textural features were extracted from manual contours of GTV on a training set. The training set consisted of PET and CT scans from 20 patients randomly selected among 45 cases with hypopharyngeal carcinoma treated with radiotherapy. All contours had been performed by experienced radiologists for treatment planning. The Jeffreys-Matusita (JM) distance, a measure of similarity between distributions, was calculated for combinations of features inside and outside the GTV respectively to choose an appropriate feature combination for segmentation of the GTV. The feature combination with the highest dissimilarity was extracted on PET and CT images from the remaining 25 HNC patients. Using these features as input for a level set segmentation method the tumours were segmented automatically. Segmentation results were evaluated against manual contours of radiologists using the DICE coefficient, and sensitivity. The result of the level set approach was compared with threshold segmentation of PET standard uptake value (SUV) of 3 or 20% of maximal intensity and tested with a paired t-test. Results: The JM analysis determined a combination of 8 textural features as appropriate for segmentation giving a distance of 1.1 out of 1.4. For the level set segmentation the DICE coefficient and sensitivity were 0.48±0.18 (mean ± standard deviation) and 0.57±0.24 respectively. Mean DICE coefficient for the 3 SUV and 20% intensity threshold segmentation were respectively 0.41±0.22 and 0.40±0.22, giving p-values of 0.04 and 0.02 for a higher DICE coefficient from the level set segmentation. For sensitivity the threshold segmentation yielded 0.52±0.24 and 0.51±0.26 for 3 SUV and 20% intensity respectively yielding p-values of 0.01 and 0.03. Conclusion: The level set method provides a more robust and stable method for segmentation of HNSCC at hypopharynx than threshold segmentation. But it should be improved in order to resemble the manual contours of radiologist. The segmentation could serve as an initial GTV estimate for manual corrections reducing both time and variance in the process of GTV contouring.
Comparison of sparse point distribution models
This paper compares several methods for obtaining sparse and compact point distribution models suited for data sets containing many variables. These are evaluated on a database consisting of 3D surfaces of a section of the pelvic bone obtained from CT scans of 33 porcine carcasses. The superior model w.r.t. sparsity, reconstruction error and interpretability is found to be a varimax rotated model with a threshold applied to small loadings. The models describe the biological variation in the database and is used for developing robotic tools when automating labor intensive procedures in slaughterhouses.
Dealing with difficult deformations: Construction of a knowledge-based deformation atlas

Twenty-three Taiwanese infants with unilateral cleft lip and palate (UCLP) were CT-scanned before lip repair at the age of 3 months, and again after lip repair at the age of 12 months. In order to evaluate the surgical result, detailed point correspondence between pre- and post-surgical images was needed. We have previously demonstrated that non-rigid registration using B-splines is able to provide automated determination of point correspondences in populations of infants without cleft lip. However, this type of registration fails when applied to the task of determining the complex deformation from before to after lip closure in infants with UCLP. The purpose of the present work was to show that use of prior information about typical deformations due to lip closure, through the construction of a knowledge-based atlas of deformations, could overcome the problem. Initially, mean volumes (atlases) for the pre- and post-surgical populations, respectively, were automatically constructed by non-rigid registration. An expert placed corresponding landmarks in the cleft area in the two atlases; this provided prior information used to build a knowledge-based deformation atlas. We model the change from pre- to post-surgery using thin-plate spline warping. The registration results are convincing and represent a first move towards an automatic registration method for dealing with difficult deformations due to this type of surgery. New or breakthrough work to be presented: The method provides a simple way of dealing with complex morphological changes using knowledge of typical deformations.

General information
State: Published
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External motion tracking for brain imaging: structured light tracking with invisible light
The importance of motion correction in 3D medical imaging increases with increasing scanner resolution. It is necessary for scanners with long image acquisition and low contrast images to correct for patient motion in order to optimize image quality. We present a near infrared structured light stereo depth map system for head motion estimation inside 3D medical scanners with limited space.
Face Detection and Recognition in Video-Streams

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Fusion of gait and fingerprint for user authentication on mobile devices

A new multi-modal biometric authentication approach using gait signals and fingerprint images as biometric traits is proposed. The individual comparison scores derived from the gait and fingers are normalized using four methods (min-max, z-score, median absolute deviation, tangent hyperbolic) and then four fusion approaches (simple sum, user-weighting, maximum score and minimum core) are applied. Gait samples are obtained by using a dedicated accelerometer sensor attached to the hip. The proposed method is evaluated using 7200 fingerprint images and gait samples. Fingerprints are collected by a capacitive line sensor, an optical sensor with total internal reflection and a touchless optical sensor. The fusion results of these two biometrics show an improved performance and a large step closer for user authentication on mobile devices.

General information
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Generating quality tetrahedral meshes from binary volumes

This paper presents two new quality measures for tetrahedra which are smooth and well-suited for gradient based optimization. Both measures are formulated as a distance from the regular tetrahedron and utilize the fact that the covariance of the vertices of a regular tetrahedron is isotropic. We use these measures to generate high quality meshes from signed distance maps. This paper also describes an approach for computing (smooth) signed distance maps from binary volumes as volumetric data in many cases originate from segmentation of objects from imaging techniques such as CT, MRI, etc. The mesh generation is split into two stages; a candidate mesh generation stage and a compression stage, where the surface of the candidate mesh is moved to the zero iso-surface of the signed distance maps, while one of the quality measures ensures that the quality remains high. We apply the mesh generation algorithm on four examples (torus, Stanford dragon, brain mask, and pig back) and report the dihedral angle, aspect ratio and radius-edge ratio. Even though, the algorithm incorporates none of the mentioned quality measures in the compression stage it receives a good score for all these measures. The minimum dihedral angle is in none of the examples smaller than $15^\circ$.

High accuracy interface characterization of three phase material systems in three dimensions

Quantification of interface properties such as two phase boundary area and triple phase boundary length is important in the characterization of many material microstructures, in particular for solid oxide fuel cell electrodes. Three-dimensional images of these microstructures can be obtained by tomography schemes such as focused ion beam serial sectioning or micro-computed tomography. We present a high accuracy method of calculating two phase surface areas and triple phase length of triple phase systems from subvoxel accuracy segmentations of constituent phases. The method performs a three phase polygonization of the interface boundaries which results in a non-manifold mesh of connected faces. We show how the triple phase boundaries can be extracted as connected curve loops without branches. The accuracy of the method is analyzed by calculations on geometrical primitives.
Improved 3D reconstruction in smart-room environments using ToF imaging

This paper presents the use of Time-of-Flight (ToF) cameras in smart-rooms and how this leads to improved results in segmenting the people in the room from the background and consequently better 3D reconstruction of foreground objects. A calibrated rig consisting of one Swissranger SR3100 Time-of-Flight range camera and a high resolution standard CCD camera is set in a smart-room containing five other standard cameras. A probabilistic background model is used to
segment each view and a shape from silhouette volume is reconstructed. It is shown that the presence of the range camera gives ways of eliminating regional artifacts and therefore creating a more robust input for higher level applications such as people tracking or human motion analysis.

General information
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BFI (2014): BFI-level 2
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Scopus rating (2013): SJR 1.102 SNIP 2.631 CiteScore 3.39
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Scopus rating (2004): SJR 1.322 SNIP 3.527
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Increasing Cone-beam projection usage by temporal fitting

A Cone-beam CT system can be used to image the lung region. The system records 2D projections which will allow 3D reconstruction however a reconstruction based on all projections will lead to a blurred reconstruction in regions were respiratory motion occur. To avoid this the projections are typically positioned on the breathing cycle using the Amsterdam shroud method [7] or some external measurement device. Measurement with similar respiratory positions are grouped as belonging to the same respiration phase. This preprocessing is known as phase binning and allows for the reconstruction of each sorted data set. The common method of choice for reconstructing the 3D volume is the Feldkamp-Davis-Kress algorithm [2], however this method suffers from serious artefacts when the sample number of projections is too low which can happen due to phase binning. Iterative methods based on solving the forward projection problem [1] are known to be more robust in these situations. We study how the lower projection limits of an iterative method can be pushed even further by modelling a temporal relation between the respiratory phases. Although phase binned data is assumed the approach will work with raw measurements. It has been suggested in [8] to circumvent the Cone beam CT(CBCT) reconstruction by utilizing an ordinary planning CT instead and learning its deformation from the CBCT projection data. The main problem with this approach is that pathological changes can cause problems. Alternatively as suggested in [6] prior knowledge of the lung deformation estimated from the planning CT could be used to include all projections into the reconstruction. It has also been attempted to estimate both the motion and 3D volume simultaneously in [4]. Problems with motion estimation are ill-posed leading to suboptimal motion which in return affects the reconstruction. By directly including time into the image representation the effect of suboptimal motion fields are avoided and we are still capable of using phase neighbour projections. The 4D image model is fitted by solving a statistical cost function based on Poissons assumptions using an L-BFGS-B optimizer [5]. It will be demonstrated on a phantom data set that the information gained from a 4D model leads to smaller reconstruction errors than a 3D iterative reconstruction based on phase binned data.

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Markov Random Field Surface Reconstruction

A method for implicit surface reconstruction is proposed. The novelty in this paper is the adaption of Markov Random Field regularization of a distance field. The Markov Random Field formulation allows us to integrate both knowledge about the type of surface we wish to reconstruct (the prior) and knowledge about data (the observation model) in an orthogonal fashion. Local models that account for both scene-specific knowledge and physical properties of the scanning device are described. Furthermore, how the optimal distance field can be computed is demonstrated using conjugate gradients, sparse Cholesky factorization, and a multiscale iterative optimization scheme. The method is demonstrated on a set of scanned human heads and, both in terms of accuracy and the ability to close holes, the proposed method is shown to have similar or superior performance when compared to current state-of-the-art algorithms.

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Motion tracking in narrow spaces: A structured light approach

We present a novel tracking system for patient head motion inside 3D medical scanners. Currently, the system is targeted at the Siemens High Resolution Research Tomograph (HRRT) PET scanner. Partial face surfaces are reconstructed using a miniaturized structured light system. The reconstructed 3D point clouds are matched to a reference surface using a robust iterative closest point algorithm. A main challenge is the narrow geometry requiring a compact structured light system and an oblique angle of observation. The system is validated using a mannequin head mounted on a rotary stage. We compare the system to a standard optical motion tracker based on a rigid tracking tool. Our system achieves an angular RMSE of 0.11 degrees demonstrating its relevance for motion compensated 3D scan image reconstructions as well as its competitiveness against the standard optical system with an RMSE of 0.08 degrees. Finally, we demonstrate qualitative result on real face motion estimation.
Multispectral colormapping using penalized least square regression

The authors propose a novel method to map a multispectral image into the device independent color space CIE-XYZ. This method provides a way to visualize multispectral images by predicting color values from spectral values while maintaining interpretability and is tested on a light emitting diode based multispectral system with a total of 11 channels in the visible area. To obtain interpretable models, the method estimates the projection coefficients with regard to their neighbors as well as the target. This results in relatively smooth coefficient curves which are correlated with the CIE-XYZ color matching functions. The target of the regression is a well known color chart, and the models are validated using leave one out cross validation in order to maintain best possible generalization ability. The authors compare the method with a direct linear regression and see that the interpretability improves significantly but comes at the cost of slightly worse predictability.
Multivariate Analysis of Variance: Finding significant growth in mice with craniofacial dysmorphology caused by the Crouzon mutation

Crouzon syndrome is characterized by growth disturbances caused by premature fusion of the cranial growth zones. A mouse model with mutation Fgfr2C342Y, equivalent to the most common Crouzon syndrome mutation (henceforth called the Crouzon mouse model), has a phenotype showing many parallels to the human counterpart. Quantifying growth in the Crouzon mouse model could test hypotheses of the relationship between craniosynostosis and dysmorphology, leading to better understanding of the causes of Crouzon syndrome as well as providing knowledge relevant for surgery planning. In the present study we used micro-CT scans of 4-week-old mice (N=5) and 6-week-old mice (N=10) with Crouzon syndrome (Fgfr2 C342Y+/) were compared to control groups of 4-week-old wild-type mice (N=5) and 6-week-old wild-type mice (N=10), respectively.

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Host publication information
On the regularization path of the support vector domain description

The internet and a growing number of increasingly sophisticated measuring devices make vast amounts of data available in many applications. However, the dimensionality is often high, and the time available for manual labelling scarce. Methods for unsupervised novelty detection are a great step towards meeting these challenges, and the support vector domain description has already shown its worth in this field. The method has recently received more attention, since it has been shown that the regularization path is piece-wise linear, and can be calculated efficiently. The presented work restates the new findings in a manner which permits the calculation with $O(n(B^2))$ complexity in each iteration step instead of $O(n(2) + n(B)(3))$, where $n$ is the number of data points and $n(B)$ is the number of boundary points. This is achieved by updating and downdating the system matrix to avoid redundant calculations. We believe this will further promote the use of this method. (C) 2010 Elsevier B.V. All rights reserved.

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Authors: Hansen, M. S. (Intern), Sjöstrand, K. (Intern), Larsen, R. (Intern)
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.719 SNIP 2.4 CiteScore 2.57
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Scopus rating (2011): SJR 0.738 SNIP 2.009 CiteScore 2.56
ISI indexed (2011): ISI indexed yes
Segmentation by Large Scale Hypothesis Testing - Segmentation as Outlier Detection

We propose a novel and efficient way of performing local image segmentation. For many applications a threshold of pixel intensities is sufficient but determine the appropriate threshold value can be difficult. In cases with large global intensity variation the threshold value has to be adapted locally. We propose a method based on large scale hypothesis testing with a consistent method for selecting an appropriate threshold for the given data. By estimating the background distribution we characterize the segment of interest as a set of outliers with a certain probability based on the estimated densities thus with what certainty the segmented object is not a part of the background. Because the method relies on local information it is very robust to changes in lighting conditions and shadowing effects. The method is applied to endoscopic images of small particles submerged in fluid captured through a microscope and we show how the method can handle transparent particles with significant glare point. The method generalizes to other problems. This is illustrated by applying the method...
to camera calibration images and MRI of the midsagittal plane for gray and white matter separation and segmentation of the corpus callosum. Comparing the methods corpus callosum segmentation to manual segmentation an average dice score of 0.86 is obtained over 40 images.

**General information**
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Publication date: 2010

**Host publication information**
Title of host publication: Proceedings of the International Conference on Computer Vision Theory and Applications
Main Research Area: Technical/natural sciences
Conference: 5th International Conference on Computer Vision Theory and Applications, Angers, France, 17/05/2010 - 17/05/2010
Source: orbit
Source-ID: 264310
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

### Segmenting the Parotid Gland using Registration and Level Set Methods

The bilateral parotid glands were segmented using a registration scheme followed by level set segmentation. A training set consisting of computerized tomography from 10 patients with segmentation of the bilateral glands were used to optimize the parameters of registration and level set segmentation. The method was evaluated on a test set consisting of 8 corresponding data sets. The attained total volume Dice coefficient and mean Hausdorff distance were 0.61 ± 0.20 and 15.6 ± 7.4 mm respectively. The method has improvement potential which could be exploited in order for clinical introduction.

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Biomedical Engineering, Department of Electrical Engineering, Copenhagen University Hospital
Authors: Hollensen, C. (Intern), Hansen, M. F. (Intern), Højgaard, L. (Intern), Specht, L. (Ekstern), Larsen, R. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences
Registration, CT, Segmentation, Head&Neck
Source: orbit
Source-ID: 265672
Publication: Research - peer-review › Poster – Annual report year: 2010

**Shape and Size from the Mist: A Deformable Model for Particle Characterization**

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Terahertz Technologies and Biophotonics, Department of Photonics Engineering
Authors: Dahl, A. L. (Intern), Jørgensen, T. M. (Intern), Gundu, P. N. (Intern), Larsen, R. (Intern)
Publication date: 2010

**Host publication information**
Title of host publication: Proceedings of VISAPP 2010
Volume: 5
Main Research Area: Technical/natural sciences
Conference: 5th International Conference on Computer Vision Theory and Applications, Angers, France, 17/05/2010 - 17/05/2010
Particle Analysis, Deconvolution, Depth Estimation, Microscopic Imaging
Electronic versions: Shape_size_infered.pdf
Source: orbit
Source-ID: 263189
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010
Structured light 3D tracking system for measuring motions in PET brain imaging

Patient motion during scanning deteriorates image quality, especially for high resolution PET scanners. A new proposal for a 3D head tracking system for motion correction in high resolution PET brain imaging is set up and demonstrated. A prototype tracking system based on structured light with a DLP projector and a CCD camera is set up on a model of the High Resolution Research Tomograph (HRRT). Methods to reconstruct 3D point clouds of simple surfaces based on phase-shifting interferometry (PSI) are demonstrated. The projector and camera are calibrated using a simple stereo vision procedure where the projector is treated as a camera. Additionally, the surface reconstructions are corrected for the non-linear projector output prior to image capture. The results are convincing and a first step toward a fully automated tracking system for measuring head motions in PET imaging.
The impact of the CAG repeat polymorphism of the androgen receptor gene on muscle and adipose tissues in 20-29-year-old Danish men: Odense Androgen Study

Background: The number of CAG repeats (CAGn) within the CAG repeat polymorphism of the androgen receptor gene correlates inversely with the transactivation of the receptor. Objective: To examine the impact of CAGn on muscle, fat distribution, and circulating androgen levels. Design, settings and participants: Population-based, cross-sectional study of 783 Danish men aged 20–29 years. Methods: Genotyping was performed in 767 men. Areas of thigh and lower trunk muscle (musclethigh and musclelower trunk), subcutaneous adipose tissues (SATthigh and SATlower trunk), and deep adipose tissues (i.m. and visceral) were measured in 393 men by magnetic resonance imaging (MRI). Lean body mass (LBM) and fat mass (FM) were measured in all men by whole body dual-energy X-ray absorptiometry (DEXA). The absolute areas acquired by MRI were the main outcomes. The absolute DEXA measurements and relative assessments of both modalities were considered as the secondary outcomes. Results: CAGn (range: 10–32) correlated inversely with absolute musclethigh (r=-0.108), absolute musclelower trunk (r=-0.132), relative musclethigh (r=-0.128), relative musclelower trunk (r=-0.126), and positively with relative SATthigh (r=0.137), relative SATlower trunk (r=0.188), relative FMlower extremity (r=0.107), and relative FMtotal (r=0.082). These relationships remained significant, controlling for physical activity, smoking, chronic disease, and age. CAGn did not correlate with any circulating androgen. Conclusions: The CAG repeat polymorphism affects body composition in young men: absolute musclethigh and absolute musclelower trunk increase as CAGn decreases. Expressed relatively, muscle areas and LBM increase, while SAT and FM decrease as CAGn decreases. The polymorphism does not affect deep adipose tissues or circulating androgen levels in young men.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Odense University Hospital
Authors: Nielsen, T. L. (Ekstern), Hagen, C. (Ekstern), Wraae, K. (Ekstern), Bathum, L. (Ekstern), Larsen, R. (Intern), Brixen, K. (Ekstern), Andersen, M. (Ekstern)
Pages: 795-804
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Endocrinology
Volume: 162
Issue number: 4
ISSN (Print): 0804-4643
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 4.11 SJR 1.674 SNIP 1.474
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.641 SNIP 1.521 CiteScore 4.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.111 SNIP 0 CiteScore 4.36
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.136 SNIP 0.251 CiteScore 3.91
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.111 SNIP 0 CiteScore 3.85
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.647 SNIP 1.468 CiteScore 3.78
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.936 SNIP 1.682
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.732 SNIP 1.029
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.565 SNIP 0.554
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.926 SNIP 1.341
Scopus rating (2006): SJR 1.282 SNIP 1.537
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.526 SNIP 0.758
Scopus rating (2004): SJR 0.974 SNIP 2.23
Scopus rating (2003): SJR 0.72 SNIP 1.682
Scopus rating (2002): SJR 0.724 SNIP 1.171
Scopus rating (2001): SJR 0.193 SNIP 0.168
Scopus rating (2000): SJR 0.844 SNIP 0.957
Scopus rating (1999): SJR 0.767 SNIP 0.917
Original language: English
DOIs:
10.1530/EJE-09-0763
Source: orbit
Source-ID: 264346
Publication: Research - peer-review › Journal article – Annual report year: 2010

Time-of-Flight Cameras in Computer Graphics
A growing number of applications depend on accurate and fast 3D scene analysis. Examples are model and lightfield acquisition, collision prevention, mixed reality, and gesture recognition. The estimation of a range map by image analysis or laser scan techniques is still a time-consuming and expensive part of such systems. A lower-priced, fast and robust alternative for distance measurements are Time-of-Flight (ToF) cameras. Recently, significant advances have been made in producing low-cost and compact ToF-devices, which have the potential to revolutionize many fields of research, including Computer Graphics, Computer Vision and Human Machine Interaction (HMI). These technologies are starting to have an impact on research and commercial applications. The upcoming generation of ToF sensors, however, will be even more powerful and will have the potential to become "ubiquitous real-time geometry devices" for gaming, web-conferencing, and numerous other applications. This STAR gives an account of recent developments in ToF-technology and discusses the current state of the integration of this technology into various graphics-related applications.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Siegen, University of Lübeck, Christian Albrechts University
Authors: Kolb, A. (Ekstern), Barth, E. (Ekstern), Koch, R. (Ekstern), Larsen, R. (Intern)
Pages: 141-159
Tumor annihilation modeling for non-diffeomorphic registration of planning and follow-up CT scans

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Copenhagen University Hospital
Authors: Bjerre, T. (Intern), Hansen, M. F. (Intern), Due, A. K. (Ekstern), Korreman, S. S. (Ekstern), Specht, L. (Ekstern), Larsen, R. (Intern)
Pages: 335-336
Publication date: 2010

Host publication information
Title of host publication: Radiotherapy & Oncology : Journal of the European Society for Therapeutic Radiotherapy and Oncology
Volume: 96
Publisher: Elsevier
Main Research Area: Technical/natural sciences
Conference: 29th European Society for Therapeutic Radiology and Oncology, Barcelona, Spain, 12/09/2010 - 12/09/2010
Links: http://www.estro-events.org/Documents/ESTRO29_abstractbook_WEB.pdf
Source: orbit
Source-ID: 276091
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2010

On parameterized deformations and unsupervised learning
The work presented here consists of contributions in three areas. An efficient algorithm for calculating the entire regularization path of the support vector domain description (SVDD) is presented. The ability to calculate the entire path with a complexity in the same order as solving the original quadratic problems gives inspiration to utilize the extra
information available from the entire path. A method for hierarchical support vector clustering, based on information from the entire regularization path, and multiple Gaussian kernels is described. Bayesian methods are applied in the attempt to draw direct statistical conclusions from the SVDD analysis.

In the context of image registration, different assumptions on the warp fields, namely diffeomorphism and a linear elastic potential in the form of regularization are discussed. A new warp representation which allows statistical analysis on an unrestricted linear parameter space, where all derivatives are defined, is introduced. Furthermore, it is shown that L2-norm the parameter space introduces a reasonable metric in the actual space of modelled diffeomorphisms. A new parametrization of 3D deformation fields, using potentials and Helmholtz decomposition is also presented. The representation can be considered a natural parametrization for both elastic and fluid image registration due to the decoupling of the parameters. The determinant gradient field is shown to be the first-order small-deformation approximation to the determinant of the Jacobian matrix.

Spline approximations of functions and in particular image registration warp fields are discussed. It is shown how spline bases may be learned from the optimization process, i.e. image registration optimization, and how this may contribute with a reasonable prior, or regularization in the method. A new formula, based on the multivariate divided difference, for explicit calculation of the simplex splines is presented. The formula additionally admits easy calculation of derivatives, both spatial, and with respect to the position of the knots. It is demonstrated that conditions may be set on the knot movements, which ensures that the splines form a partition of unity, even if the knots are not Delaunay. A subdivision scheme is also presented, which requires no recalculation of the configurations of the splines. The use of the splines for image registration is demonstrated, and the inherent smoothing or averaging cost of selecting warp parameterizations at a specific kernel resolution, has been analyzed. A refinement measure has been derived, which is shown to be efficient for guiding the local mesh layout. With the combination of the refinement measure and the local flexibility of the multivariate B-splines, the warp field is automatically refined in areas where it results in the minimization of the registration cost function.

General information
State: Published
Organizations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, DTU Data Analysis
Authors: Hansen, M. S. (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern)
Number of pages: 144
Publication date: Nov 2009

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
Series: IMM-PHD-2009-219
Main Research Area: Technical/natural sciences
Electronic versions:
phd219_Hansen_MS.pdf
Source: orbit
Source-ID: 249932
Publication: Research › Ph.D. thesis – Annual report year: 2009

The virtual knife
Since post World War II and until 2008 the Danish pig producing industry (DPPI) has been in a continuing state of growth. In spite of an ever fiercer competition DPPI has managed to protect its position as export leader by maintaining a focus on research and development. Today, DPPI is in a state of recession and must increase the efficiency if not to reduce the production capacity further. The industry recognizes that a more efficient use of the raw materials is one of the largest and most important challenges. To meet this challenge it is a necessity to get a better understanding of the biological variation of pigs. The development of models for describing the biological variation of pigs is one of the key components needed to attain a better sorting of the pig carcasses and an improved cutting in the abattoirs. Such models can be related to possible products, which can be related to potential yield and order books. The Danish Meat Research Institute (DMRI) is currently constructing a representative database of virtual representations of pigs using X-ray Computed Tomography (CT). The database will serve as the foundation for the diversity modeling of pigs and for extracting predictors of quality and optimal use. This thesis integrates well-known techniques from the medical image analysis into the development of tools for automated analysis of the morphology of pigs. E.g. elastic image matching has been applied to establish spatial correspondence between the virtual representations of pigs in the database. The establishment of spatial correspondence is an essential preprocessing step for most automated analysis using the database.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Department of Photonics Engineering
Image Registration and Optimization in the Virtual Slaughterhouse

This thesis presents the development and application of algorithms for the analysis of pig carcasses. Focus is on the simulation and quality estimation of meat products produced in a Danish slaughterhouse. Computed Tomography scans of pig carcasses provide the data used in the application. Image analysis is applied in order to imitate some of the cutting processes found in a slaughterhouse but also to give a quantitative measure of the composition of each carcass. The basis of the algorithms is non-linear image registration. This method finds the anatomical correspondence between a reference carcass and a template carcass. By iteratively comparing the transformed template with the reference a resulting dense deformation field is found. Propagating a set of landmarks from the reference coordinate system onto the template enables the simulation of slaughtering processes. Non-invasively estimating the quality of the slaughtering products provides a very valuable tool for use in the slaughterhouse in the future.

Modeling the Biological Diversity of Pig Carcasses

This thesis applies methods from medical image analysis for modeling the biological diversity of pig carcasses. The Danish meat industry is very focused on improving product quality and productivity by optimizing the use of the carcasses and increasing productivity in the abattoirs. In order to achieve these goals there is a need for more detailed information about pig carcasses in relation to measures of quality. Non-invasive imaging such as X-ray Computed Tomography (CT) can provide this very detailed information discerning the major tissue types. Medical image analysis provides the tools for extracting and modeling meaningful information from the vast amount of information available from non-invasive imaging data. The lean meat percentage (LMP) is a common standard for measuring the quality of pig carcasses. Measuring the LMP using CT and using this as a reference for calibration of online equipment is investigated, without the need for a calibration against a less accurate manual dissection. The rest of the contributions regard the construction and use of point distribution models (PDM). PDM’s are able to capture the shape variation of a population of shapes, in this case a 3D surface of a specific bone structure in the ham. These models can assist developers of robotic tools by enabling population based testing before actual construction of the tools. Sparse models are compared to the standard PCA based model and a method for fitting PDM’s to sparse data is proposed. The former provides more spatially localized modes of variation that are easier interpretable and the latter enables the use of PDM’s without the need for full point correspondence of new data. There is great potential in applying CT as non-invasive modality in the meat industry, e.g. in population based studies, for shape modeling and for analyzing carcass composition. In the future online CT applications can be used to make decisions on the use of each specific carcass by obtaining improved quality measures.
4D Lung Reconstruction with Phase Optimization

This paper investigates and demonstrates a 4D lung CT reconstruction/registration method which results in a complete volumetric model of the lung that deforms according to a respiratory motion field. The motion field is estimated iteratively between all available slice samples and a reference volume which is updated on the fly. The method is two part and the second part of the method aims to correct wrong phase information by employing another iterative optimizer. This two part iterative optimization allows for complete reconstruction at any phase and it will be demonstrated that it is better than using an optimization which does not correct for phase errors. Knowing how the lung and any tumors located within the lung deforms is relevant in planning the treatment of lung cancer.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Odense University Hospital
Authors: Lyksborg, M. (Intern), Paulsen, R. (Intern), Brink, C. (Ekstern), Larsen, R. (Intern)
Pages: 2227-2230
Publication date: 2009

Host publication information
Title of host publication: IFMBE Proceedings
Volume: 25/4
Place of publication: Munich
Publisher: Springer Berlin Heidelberg
Main Research Area: Technical/natural sciences
Conference: World Congress on Medical Physics and Biomedical Engineering, Munich, Germany, 07/09/2009 - 07/09/2009
Analysis of gait using a treadmill and a Time-of-flight camera
We present a system that analyzes human gait using a treadmill and a Time-of-flight camera. The camera provides spatial data with local intensity measures of the scene, and data are collected over several gait cycles. These data are then used to model and analyze the gait. For each frame the spatial data and the intensity image are used to fit an articulated model to the data using a Markov random field. To solve occlusion issues the model movement is smoothened providing the missing data for the occluded parts. The created model is then cut into cycles, which are matched and through Fourier fitting a cyclic model is created. The output data are: Speed, Cadence, Step length and Range-of-motion. The described output parameters are computed with no user interaction using a setup with no requirements to neither background nor subject clothing.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Jensen, R. R. (Intern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
Pages: 154-166
Publication date: 2009

Host publication information
Title of host publication: Dynamic 3D Imaging
Place of publication: Heidelberg
Publisher: Springer
ISBN (Print): 978-3-642-03777-1
Main Research Area: Technical/natural sciences
Conference: Dynamic 3D Imaging, 01/01/2009
gait analysis, motion capture, computer vision, Markov random fields, Time-of-flight camera
Source: orbit
Source-ID: 250818
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Analyzing Gait Using a Time-Of-Flight Camera
An algorithm is created, which performs human gait analysis using spatial data and amplitude images from a Time-of-flight camera. For each frame in a sequence the camera supplies cartesian coordinates in space for every pixel. By using an articulated model the subject pose is estimated in the depth map in each frame. The pose estimation is based on likelihood, contrast in the amplitude image, smoothness and a shape prior used to solve a Markov random field. Based on the pose estimates, and the prior that movement is locally smooth, a sequential model is created, and a gait analysis is done on this model. The output data are: Speed, Cadence (steps per minute), Step length, Stride length (stride being two consecutive steps also known as a gait cycle), and Range of motion (angles of joints). The created system produces good output data of the described output parameters and requires no user interaction.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Jensen, R. R. (Intern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
Publication date: 2009

Host publication information
Title of host publication: Proceedings of the Scandinavian Conference on Image Analysis
Place of publication: Heidelberg
Publisher: Springer
Main Research Area: Technical/natural sciences
Conference: 16th Scandinavian Conference on Image Analysis (SCIA), Oslo, Norway, 15/06/2009 - 15/06/2009
gait analysis, computer vision, Markov random fields, Time-of-flight camera
Source: orbit
Source-ID: 245804
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009
Automatic Assessment of Craniofacial Growth in a Mouse Model of Crouzon Syndrome

BACKGROUND & PURPOSE: Crouzon syndrome is characterized by growth disturbances caused by premature craniosynostosis. A mouse model with mutation Fgfr2C342Y, equivalent to the most common Crouzon syndrome mutation (henceforth called the Crouzon mouse model), has a phenotype showing many parallels to the human counterpart. Quantifying growth in the Crouzon mouse model could test hypotheses of the relationship between craniosynostosis and dysmorphology, leading to better understanding of the causes of Crouzon syndrome as well as providing knowledge relevant for surgery planning.

METHODS: Automatic non-rigid volumetric image registration was applied to micro-CT scans of ten 4-week and twenty 6-week euthanized mice for growth modeling. Each age group consisted of 50% normal and 50% Crouzon mice. Four 3D mean shapes, one for each mouse-type and age group were created. Extracting a dense field of growth vectors for each mouse-type; growth models were created using linear interpolation and visualized as 3D animations. Spatial regions of significantly different growth were identified using the local False Discovery Rate method, estimating the expected percentage of false predictions in a set of predictions. For all image registrations, the Image Registration Toolkit was used under Licence from Ixico Ltd.

RESULTS: Investigation proved growth in the Crouzon group to be inhibited, especially in the nasal and posterior regions of the skull compared to the growth in the normal group, and showed an expansion vertically and laterally in the middle and anterior part of the calvaria. Image registration was used to automatically obtain landmarks, thus, different skull measures could be performed e.g. length, width, height. The registrations were quantitatively validated using expert-placed landmarks.

CONCLUSIONS: Image registrations made it possible to automatically quantify and visualize average craniofacial growth in normal and Crouzon mouse models, and significantly different growth patterns were found between the two. The methodology generalizes to quantification of shape and growth in other mouse models, and provides a tool for spatially detailed automatic phenotyping.

MAIN OBJECTIVES OF PRESENTATION: We will present a 3D growth model of normal and Crouzon mice, and differences will be statistically and visually compared.
For this modelling task Markov Random Fields are suitable. Markov Random Fields have, however, previously been plagued by lack of efficient optimization methods or numerical solvers. We here address the issue of efficient incorporation of local homogeneity constraints into change detection algorithms. We do this by exploiting recent advances in graph based algorithms for Markov Random Fields. This is combined with an IR-MAD change detector, and demonstrated on real data with good results.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Geodesy, National Space Institute
Authors: Aanæs, H. (Intern), Nielsen, A. A. (Intern), Carstensen, J. M. (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern)
Publication date: 2009

Host publication information
Title of host publication: IEEE International Geoscience and remote sensing symposium
Volume: 3
Publisher: IEEE
ISBN (Print): 978-1-4244-3394-0
Main Research Area: Technical/natural sciences
Markov Random Fields, IR-MAD, Homogeneity Constraints, Graph Based Algorithms, Change Detection
Electronic versions:
IGARSS2009_0300689.pdf
DOIs:
10.1109/IGARSS.2009.5417856

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Source: orbit
Source-ID: 248644
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Kernel based subspace projection of hyperspectral images
In hyperspectral image analysis an exploratory approach to analyse the image data is to conduct subspace projections. As linear projections often fail to capture the underlying structure of the data, we present kernel based subspace projections of PCA and Maximum Autocorrelation Factors (MAF). The MAF projection exploits the fact that interesting phenomena in images typically exhibit spatial autocorrelation. The analysis is based on nearinfrared hyperspectral images of maize grains demonstrating the superiority of the kernelbased MAF method.

General information
State: Published
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Amgren, M. (Intern), Hansen, P. W. (Ekstern)
Publication date: 2009
Event: Poster session presented at European Workshop on Challenges in Modern Massive Data Sets, Kgs. Lyngby, Denmark, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 256956
Publication: Research - peer-review › Poster – Annual report year: 2009

Kernel based subspace projection of near infrared hyperspectral images of maize kernels
In this paper we present an exploratory analysis of hyper- spectral 900-1700 nm images of maize kernels. The imaging device is a line scanning hyper spectral camera using a broadband NIR illumi- nation. In order to explore the hyperspectral data we compare a series of subspace projection methods including principal component analysis and maximum autocorrelation factor analysis. The latter utilizes the fact that interesting phenomena in images exhibit spatial autocorrelation. However, linear projections often fail to grasp the underlying variability on the data. Therefore we propose to use so-called kernel version of the two afore-mentioned methods. The kernel methods implicitly transform the data to a higher dimensional space using non-linear transformations while retaining the computational complexity. Analysis on our
data example illustrates that the proposed kernel maximum autocorrelation factor transform outperform the linear methods as well as kernel principal components in producing interesting projections of the data.

**General information**

State: Published
Authors: Larsen, R. (Intern), Arngren, M. (Intern), Hansen, P. W. (Ekstern), Nielsen, A. A. (Intern)
Publication date: 2009

**Host publication information**

Title of host publication: Proceedings on the 16th Scandinavian Conference on Image Analysis
Place of publication: New York
Publisher: Springer
Editor: Salberg, A.

Series: Lecture Notes in Computer Science
Main Research Area: Technical/natural sciences
Conference: 16th Scandinavian Conference on Image Analysis, Oslo, Norway, 15/06/2009 - 15/06/2009

Links:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5744
Source: orbit
Source-ID: 240780
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

**Kvalitet afhænger af måling og modellering**

**General information**

State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, DTU Data Analysis
Authors: Jørgensen, S. B. (ed.) (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences

**Publication information**

Journal: FoodDTU Midt i Ugen
Issue number: 101
Original language: Danish
Source: orbit
Source-ID: 257854
Publication: Communication › Journal article – Annual report year: 2009

Predictive Modelling of Cardiac 2D Multi-Slice MRI with Simultaneous Resolution of Cardiac and Respiratory Motion

This paper introduces a novel approach to modelling of volumetric cardiac magnetic resonance imaging (MRI) with simultaneous resolution of cardiac and respiratory motion. The major challenge is that the inherent slow nature of MRI prevents obtaining real-time volumetric images of the heart with sufficient spatial and temporal resolution. To overcome this problem our method predicts pixel intensities in multiple 2D slices, acquired with high spatial and temporal resolution, and subsequently assembles these into volumetric data sets. The prediction is based on external motion sensors, in our case a respiratory bellow and a vectorcardiogram, and utilizes a combination of deformation modelling and pixel intensity modelling. We demonstrate that this approach reliably models volumetric cardiac MRI for any combination of cardiac and respiratory phase.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Copenhagen University Hospital
Authors: Pedersen, H. (Ekstern), Ólafsdóttir, H. (Intern), Darkner, S. (Intern), Lyksborg, M. (Intern), Larsen, R. (Intern)
Pages: 125-131
Publication date: 2009

**Host publication information**

Title of host publication: proceedings of CI2BM09 - MICCAI Workshop on Cardiovascular Interventional Imaging and Biophysical Modelling
Main Research Area: Technical/natural sciences
Predictive modelling of cardiac real-time 2D images

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Copenhagen University Hospital
Authors: Pedersen, H. (Ekstern), Larsson, H. B. W. (Ekstern), Larsen, R. (Intern)
Number of pages: 5,363
Publication date: 2009

Host publication information
Title of host publication: Proceedings 17th Scientific Meeting, International Society for Magnetic Resonance in Medicine
Main Research Area: Technical/natural sciences
Conference: 17th Scientific Meeting, International Society for Magnetic Resonance in Medicine, Honolulu, HI, United States, 18/04/2009 - 18/04/2009
Source: orbit
Source-ID: 252525
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Reconstruction of free-breathing myocardial perfusion MRI using simultaneous modeling of perfusion and motion (SMPM) and arbitrary k-space sampling

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Copenhagen University Hospital
Authors: Pedersen, H. (Ekstern), Larsson, H. B. W. (Ekstern), Larsen, R. (Intern)
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Title of host publication: Proceedings of the 17th Scientific Meeting, International Society for Magnetic Resonance in Medicine
Main Research Area: Technical/natural sciences
Conference: 17th Scientific Meeting, International Society for Magnetic Resonance in Medicine, Honolulu, HI, United States, 18/04/2009 - 18/04/2009
Source: orbit
Source-ID: 252526
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Regularisation of 3D Signed Distance Fields
Signed 3D distance fields are used a in a variety of domains. From shape modelling to surface registration. They are typically computed based on sampled point sets. If the input point set contains holes, the behaviour of the zero-level surface of the distance field is not well defined. In this paper, a novel regularisation approach is described. It is based on energy formulation, where both local smoothness and data fidelity are included. The minimisation of the global energy is shown to be the solution of a large set of linear equations. The solution to the linear system is found by sparse Cholesky factorisation. It is demonstrated that the zero-level surface will act as a membrane after the proposed regularisation. This effectively closes holes in a predictable way. Finally, the performance of the method is tested with a set of synthetic point clouds of increasing complexity.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Paulsen, R. R. (Intern), Bærentzen, J. A. (Intern), Larsen, R. (Intern)
Pages: 513-519
Shape Analysis Using the Auto Diffusion Function

Scalar functions defined on manifold triangle meshes is a starting point for many geometry processing algorithms such as mesh parametrization, skeletonization, and segmentation. In this paper, we propose the Auto Diffusion Function (ADF) which is a linear combination of the eigenfunctions of the Laplace-Beltrami operator in a way that has a simple physical interpretation. The ADF of a given 3D object has a number of further desirable properties: Its extrema are generally at the tips of features of a given object, its gradients and level sets follow or encircle features, respectively, it is controlled by a single parameter which can be interpreted as feature scale, and, finally, the ADF is invariant to rigid and isometric deformations. We describe the ADF and its properties in detail and compare it to other choices of scalar functions on manifolds. As an example of an application, we present a pose invariant, hierarchical skeletonization and segmentation algorithm which makes direct use of the ADF.
Shape and Texture Based Classification of Fish Species

In this paper we conduct a case study of fish species classification based on shape and texture. We consider three fish species: cod, haddock, and whiting. We derive shape and texture features from an appearance model of a set of training data. The fish in the training images were manual outlined, and a few features including the eye and backbone contour were also annotated. From these annotations an optimal MDL curve correspondence and a subsequent image registration were derived. We have analyzed a series of shape and texture and combined shape and texture modes of variation for their ability to discriminate between the fish types, as well as conducted a preliminary classification. In a linear discriminant analysis based on the two best combined modes of variation we obtain a resubstitution rate of 76%.

Abstract A growing number of applications depend on accurate and fast 3D scene analysis. Examples are model and lightfield acquisition, collision prevention, mixed reality, and gesture recognition. The estimation of a range map by image analysis or laser scan techniques is still a time-consuming and expensive part of such systems. A lower-priced, fast and robust alternative for distance measurements are Time-of-Flight (ToF) cameras. Recently, significant improvements have been made in order to achieve low-cost and compact ToF-devices, that have the potential to revolutionize many fields of research, including Computer Graphics, Computer Vision and Man Machine Interaction (MMI). These technologies are starting to have an impact on research and commercial applications. The upcoming generation of ToF sensors, however, will be even more powerful and will have the potential to become “ubiquitous real-time geometry devices” for gaming, web-conferencing, and numerous other applications. This STAR gives an account of recent developments in ToF-technology and discusses the current state of the integration of this technology into various graphics-related applications.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Siegen, University of Lübeck, Christian Albrechts University
Authors: Kolb, A. (Ekstern), Barth, E. (Ekstern), Koch, R. (Ekstern), Larsen, R. (Intern)
Publication date: 2009

Host publication information
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Editors: Pauly, M., Greiner, G.
Main Research Area: Technical/natural sciences
Conference: 30th Annual Conference of the European Association for Computer Graphics, Munich, Germany, 30/03/2009 - 30/03/2009
Source: orbit
Source-ID: 252537
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009
Unsupervised Assessment of Subcutaneous and Visceral Fat by MRI

This paper presents a method for unsupervised assessment of visceral and subcutaneous adipose tissue in the abdominal region by MRI. The identification of the subcutaneous and the visceral regions were achieved by dynamic programming constrained by points acquired from an active shape model. The combination of active shape models and dynamic programming provides for a both robust and accurate segmentation. The method features a low number of parameters that give good results over a wide range of values. The unsupervised segmentation was compared with a manual procedure and the correlation between the manual segmentation and unsupervised segmentation was considered high.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Odense University Hospital
Authors: Jørgensen, P. S. (Intern), Larsen, R. (Intern), Wraae, K. (Ekstern)
Pages: 179-188
Publication date: 2009

Host publication information
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Volume: 5575
Publisher: Springer
ISBN (Print): 978-3-642-02229-6

Series: Lecture Notes in Computer Science
Main Research Area: Technical/natural sciences
Conference: 16th Scandinavian Conference on Image Analysis (SCIA), Oslo, Norway, 15/06/2009 - 15/06/2009
Source: orbit
Source-ID: 241268
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Virtual dissection of pig carcasses

This paper proposes the use of computed tomography (CT) as a reference method for estimating the lean meat percentage (LMP) of pig carcasses. The current reference is manual dissection which has a limited accuracy due to variability between butchers. A contextual Bayesian classification scheme is applied to classify volume elements of full body CT-scans of pig carcasses into three tissue types. A linear model describes the relation between voxels and the full weight of the half carcass, which can be determined more accurately than that of the lean meat content. Two hundred and ninety-nine half pig carcasses were weighed and CT-scanned. The explained variance of the model was $R^2 = 0.9994$ with a root-mean-squared error of prediction of 83.6 g. Applying this method as a reference will ensure a more robust calibration of sensors for measuring the LMP, which is less prone to variation induced by manual intervention.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, DTU Data Analysis
Authors: Vester-Christensen, M. (Intern), Erbou, S. G. H. (Intern), Hansen, M. F. (Intern), Olsen, E. (Ekstern), Christensen, L. (Ekstern), Hviid, M. (Ekstern), Ersbøll, B. K. (Intern), Larsen, R. (Intern)
Pages: 699-704
Publication date: 2009
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.33 SJR 1.734 SNIP 1.945
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.92 SNIP 1.85 CiteScore 3.04
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.488 SNIP 1.878 CiteScore 2.94
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.506 SNIP 1.848 CiteScore 2.9
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.655 SNIP 1.884 CiteScore 2.84
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.761 SNIP 1.797 CiteScore 2.75
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.547 SNIP 1.621
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.34 SNIP 1.511
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.298 SNIP 1.409
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.026 SNIP 1.628
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.144 SNIP 1.634
Scopus rating (2005): SJR 0.84 SNIP 1.533
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.079 SNIP 1.692
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.782 SNIP 1.554
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.782 SNIP 1.286
Scopus rating (2001): SJR 0.851 SNIP 1.278
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.772 SNIP 1.447
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.727 SNIP 1.286
Original language: English
Calibration reference, Pig carcass grading, Computed tomography, Lean meat percentage, Image analysis
DOIs:
10.1016/j.meatsci.2008.11.015
Source: orbit
Monitoring angiogenesis using magnetic resonance methods

When a tumor reaches a certain size it can no longer rely on passive perfusion for nutrition. The tumor therefore emits signaling molecules which stimulating surrounding vessels to divide and grow towards the tumor, a process known as angiogenesis. Very little angiogenesis is present in healthy adults where it is primarily found in wound healing, pregnancy and during the menstrual cycle. This thesis focus on the negative consequences of angiogenesis in cancer. It consists of an initial overview followed by four manuscripts. The overview gives a short introduction to the process of angiogenesis and the involved signaling molecules. Subsequently, a short review of contrast agents and perfusion measurements is given. Finally, methods for monitoring angiogenesis using magnetic resonance imaging are reviewed. A method for monitoring early stages of angiogenesis as well as the effect of anti-angiogenic treatment is presented in the first manuscript. In the second and third manuscript, two separate methods of quantifying perfusion, blood volume and vessel permeability are presented. The methods are used to show that drug delivery to a xenografted tumor is plausible and to show possible vascular maturation in a transgenic mouse model. The last manuscript presents a new method for in vivo cell labeling. This method could find use in studying the metastatic spread of cancer cells throughout the body.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Holm, D. A. (Intern), Sidaros, K. (Intern), Larsen, R. (Intern)
Number of pages: 130
Publication date: Nov 2008

Publication information
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Main Research Area: Technical/natural sciences
Electronic versions: phd199_dah.pdf
Source: orbit
Source-ID: 220416
Publication: Research › Ph.D. thesis – Annual report year: 2008

Analysis of Craniofacial Images using Computational Atlases and Deformation Fields

The topic of this thesis is automatic analysis of craniofacial images. The methods proposed and applied contribute to the scientific knowledge about different craniofacial anomalies, in addition to providing tools for detailed and robust analysis of craniofacial images for clinical and research purposes. The basis for most of the applications is non-rigid image registration. This approach brings one image into the coordinate system of another resulting in a deformation field describing the anatomical correspondence between the two images. A computational atlas representing the average anatomy of a group may be constructed and brought into correspondence with a set of images of interest. Having established such a correspondence, various analyses may be carried out. This thesis discusses two types of such analyses, i.e. statistical deformation models and novel approaches for the quantification of asymmetry. The analyses are applied to the study of three different craniofacial anomalies. The craniofacial applications include studies of Crouzon syndrome (in mice), unicoronal synostosis plagiocephaly and deformational plagiocephaly. Using the proposed methods, the thesis reveals novel findings about the craniofacial morphology and asymmetry of Crouzon mice. Moreover, a method to plan and evaluate treatment of children with deformational plagiocephaly, based on asymmetry assessment, is established. Finally, asymmetry in children with unicoronal synostosis is automatically assessed, confirming previous results based on manual reference points and providing a higher level of detail.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, DTU Data Analysis
Authors: Ólafsdóttir, H. (Intern), Ersbøll, B. K. (Intern), Larsen, R. (Intern)
Number of pages: 159
Publication date: Apr 2008

Publication information
Original language: English
Series: IMM-PHD-2008-187
ISSN: 0909-3192
Main Research Area: Technical/natural sciences
Adaptive Parametrization of Multivariate B-splines for Image Registration

We present an adaptive parametrization scheme for dynamic mesh refinement in the application of parametric image registration. The scheme is based on a refinement measure ensuring that the control points give an efficient representation of the warp fields, in terms of minimizing the registration cost function. In the current work we introduce multivariate B-splines as a novel alternative to the widely used tensor B-splines enabling us to make efficient use of the derived measure. The multivariate B-splines of order $n$ are $C^{n-1}$ smooth and are based on Delaunay configurations of arbitrary 2D or 3D control point sets. Efficient algorithms for finding the configurations are presented, and B-splines are through their flexibility shown to feature several advantages over the tensor B-splines. In spite of efforts to make the tensor product B-splines more flexible, the knots are still bound to reside on a regular grid. In contrast, by efficient non-constrained placement of the knots, the multivariate B-splines are shown to give a good representation of inhomogeneous objects in natural settings. The wide applicability of the method is illustrated through its application on medical data and for optical flow estimation.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Technische Universität München
Authors: Hansen, M. S. (Intern), Glocker, B. (Ekstern), Navab, N. (Ekstern), Larsen, R. (Intern)
Pages: 1-8
Publication date: 2008

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Copyright: 2008 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE
Source: orbit
Source-ID: 228460
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

A generalization of voxel-wise procedures for high-dimensional statistical inference using ridge regression

Whole-brain morphometry denotes a group of methods with the aim of relating clinical and cognitive measurements to regions of the brain. Typically, such methods require the statistical analysis of a data set with many variables (voxels and exogenous variables) paired with few observations (subjects). A common approach to this ill-posed problem is to analyze each spatial variable separately, dividing the analysis into manageable subproblems. A disadvantage of this method is that the correlation structure of the spatial variables is not taken into account. This paper investigates the use of ridge regression to address this issue, allowing for a gradual introduction of correlation information into the model. We make the connections between ridge regression and voxel-wise procedures explicit and discuss relations to other statistical methods. Results are given on an in-vivo data set of deformation based morphometry from a study of cognitive decline in an elderly population.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of California, San Francisco
Authors: Sjöstrand, K. (Intern), Cardenas, V. A. (Ekstern), Larsen, R. (Intern), Studholme, C. (Ekstern)
Number of pages: 12
Analysis of Surfaces Using Constrained Regression Models

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Computer Science and Artificial Intelligence Laboratory
Authors: Darkner, S. (Intern), Sabuncu, M. R. (Ekstern), Golland, P. (Ekstern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
Pages: 842-849
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the SPIE : Medical Imaging 2008: Image Processing
Volume: 6914
Publisher: SPIE - International Society for Optical Engineering
Main Research Area: Technical/natural sciences
DOI: 10.1117/12.770728
Source: orbit
Source-ID: 239931
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Cluster Tracking with Time-of-Flight Cameras

We describe a method for tracking people using a time-of-flight camera and apply the method for persistent authentication in a smart-environment. A background model is built by fusing information from intensity and depth images. While a geometric constraint is employed to improve pixel cluster coherence and reducing the influence of noise, the EM algorithm (expectation maximization) is used for tracking moving clusters of pixels significantly different from the background model. Each cluster is defined through a statistical model of points on the ground plane. We show the benefits of the time-of-flight principles for people tracking but also their current limitations.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Technical University of Denmark
Authors: Hansen, D. W. (Intern), Hansen, M. (Ekstern), Kirschmeyer, M. (Ekstern), Larsen, R. (Intern), Silvestre, D. (Ekstern)
Pages: 1-6
Publication date: 2008

Host publication information
Title of host publication: Computer Vision and Pattern Recognition Workshops : Time-of-flight based computer vision
Publisher: IEEE Computer Society Press
Main Research Area: Technical/natural sciences
Electronic versions:
Hansen2.pdf
Computing Minimal Deformations: Application to Construction of Statistical Shape Models

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Technische Universität München
Authors: Zikic, D. (Ekstern), Hansen, M. S. (Intern), Glocker, B. (Ekstern), Kameme, A. (Ekstern), Larsen, R. (Intern), Navab, N. (Ekstern)
Publication date: 2008

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Source: orbit
Source-ID: 228458
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Conditional Statistical Model Building

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Hansen, M. F. (Intern), Hansen, M. S. (Intern), Larsen, R. (Intern)
Publication date: 2008

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Main Research Area: Technical/natural sciences
Conference: 2008 International Symposium on Medical Imaging, San Diego, CA, United States, 16/02/2008 - 16/02/2008
DOIs:
10.1117/12.771079
Links:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5514
Source: orbit
Source-ID: 205557
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Fusion of stereo vision and Time-Of-Flight imaging for improved 3D estimation

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Guðmundsson, S. Á. (Intern), Aanæs, H. (Intern), Larsen, R. (Intern)
Pages: 425 - 433
Publication date: 2008
L 1 Generalized Procrustes 2D Shape Alignment

This paper describes a new method for resistant and robust alignment of sets of 2D shapes wrt. position, rotation, and isotropical scaling. Apart from robustness a major advantage of the method is that it is formulated as a linear programming (LP) problem, thus enabling the use of well known and thoroughly tested standard numerical software. The problem is formulated as the minimization of the norm of a linear vector function with a contraint of non-zero size. This is achieved by using the city block distance between points in the plane. Unfortunately the city block distance is dependent on the orientation of the coordinate system, i.e. it is not rotationally invariant. However, by simultaneously minimizing the city block distances in a series of rotated coordinate systems we are able to approximate the circular equidistance curves of Euclidean distances with a regular polygonal equidistance curve to the precision needed. Using 3 coordinate systems rotated 30 degrees we get a 12 sided regular polygon, with which we achieve deviations from Euclidean distances less than 2 % over all directions. This new formulation allows for minimization in the L1-norm using LP. We demonstrate that the use of the L1-norm results in resistance towards object as well as landmark outliers. Examples that illustrate the properties of the robust norm are given on simulated as well as medical data sets.
Multiscale Hierarchical Support Vector Clustering

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Hansen, M. S. (Intern), Holm, D. A. (Intern), Sjöstrand, K. (Intern), Ley, K. D. (Ekstern), Rowland, I. J. (Ekstern), Larsen, R. (Intern)
Publication date: 2008

Host publication information
Title of host publication: International Symposium on Medical Imaging 2008
Publisher: SPIE - International Society for Optical Engineering
Main Research Area: Technical/natural sciences
Conference: 2008 International Symposium on Medical Imaging, San Diego, CA, United States, 16/02/2008 - 16/02/2008
Links: http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5513
Source: orbit
Source-ID: 205555
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

TOF Imaging in Smart Room Environments towards Improved People Tracking
In this paper we present the use of Time-of-Flight (TOF) cameras in Smart-rooms and how this leads to improved results in segmenting the people in the room from the background and consequently better 3D reconstruction of the people. A calibrated rig of one Swissranger SR3100 Time-of-flight range camera and a high resolution standard camera is set in a smart-room consisting of 5 other standard cameras. A probabilistic background model is used to segment each view and a shape from silhouette 3D volume is constructed. It is shown that the presence of the range camera gives ways of eliminating regional artifacts and therefore a more robust input for higher level applications such people tracking or human motion analysis.

General information
Accelerated 3D image registration

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Vester-Christensen, M. (Intern), Erbou, S. G. (Intern), Darkner, S. (Intern), Larsen, R. (Intern)
Publication date: 2007

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Title of host publication: SPIE Medical Imaging 2007
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5045
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Source-ID: 195666
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Advances in radiologic image analysis from MICCAI 2006

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Niessen, W. (Ekstern)
Pages: 1296-1297
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Academic Radiology
Volume: 14
Issue number: 11
ISSN (Print): 1076-6332
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): SJR 0.935 SNIP 0.988 CiteScore 1.87
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.008 SNIP 0.986 CiteScore 1.9
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.957 SNIP 0.984 CiteScore 1.75
Deformational Plagiocephaly (DP) is a term describing head asymmetry and deformation commonly seen in infants. DP affects the back of the head and, to a lesser extent, the forehead. The deformity is thought to result from protracted external pressure to the skull in one position. Treatment is non-surgical and involves parental education on infant repositioning to avoid pressure on the atented side, and, in many cases, orthotic molding helmet therapy. The purpose of this work was to develop a method for assessment of helmet therapy employing a statistical analysis of change in head asymmetry. The clinical population consisted of 37 infants for whom 3D surface scans of the head had been obtained both before and after their helmet treatment. Detailed point correspondence between all head surfaces was established by tps-transforming a symmetric template to each of the head surfaces. This also ensured full left-right point correspondence. Asymmetry was quantified by the ratio of distances between sides, measured from a midpoint between the ears to corresponding surface points on opposite sides of the midsagittal plane. The method was able to quantify and localize the asymmetry, which occurred predominantly in the back and/or the front of the head. Change in asymmetry was determined by computing the difference between measurement before and after the therapy. The results revealed that the head asymmetry was, in most cases, corrected in the posterior and/or anterior regions. The values of asymmetry change were statistically analyzed using Principal Components Analysis. The model localized the two major improvements to the posterior and anterior regions of the head, respectively, where also the main head asymmetries had been detected (and clinically observed). Results deem this method suitable for treatment evaluation. In addition, results establish helmet therapy as an effective treatment for improving head asymmetry in infants with DP.

General information

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering, Image Analysis and Computer Graphics
An Active Illumination and Appearance (AIA) Model for Face Alignment

Face recognition systems are typically required to work under highly varying illumination conditions. This leads to complex effects imposed on the acquired face image that pertains little to the actual identity. Consequently, illumination normalization is required to reach acceptable recognition rates in face recognition systems. In this paper, we propose an approach that integrates the face identity and illumination models under the widely used Active Appearance Model framework as an extension to the texture model in order to obtain illumination-invariant face localization.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Kahraman, F. (Intern), Gokmen, M. (Ekstern), Darkner, S. (Intern), Larsen, R. (Intern)
Publication date: 2007

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ISBN (Print): 1-4244-1180-7
Main Research Area: Technical/natural sciences
faces, texture, shape, illumination, aam
DOIs: 10.1109/CVPR.2007.383399
Source: orbit
Source-ID: 200179
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Analysis of Deformation of the Human Ear and Canal Caused by Mandibular Movement

Many hearing aid users experience physical discomfort when wearing their device. The main contributor to this problem is believed to be deformation of the ear and ear canal caused by movement of the mandible. Physical discomfort results from added pressure on soft tissue areas in the ear. Identifying features that can predict potential deformation is therefore important for identifying problematic cases in advance. A study on the physical deformation of the human ear and canal due to movement of the mandible is presented. The study is based on laser scanings of 30 pairs of ear impressions from 9 female and 21 male subjects. Two impressions have been taken from each subject, one with open mouth, and one with the mouth closed. All impressions are registered using non-rigid surface registration and a shape model is built. From each pair of impressions a deformation field is generated and propagated to the shape model, enabling the building of a deformation model in the reference frame of the shape model. A relationship between the two models is established, showing that the shape variation can explain approximately 50% of the variation in the deformation model. An hypothesis test for significance of the deformations for each deformation field reveals that all subjects have significant deformation at Tragus and in the canal. Furthermore, a relation between the magnitude of the deformation and the gender of the subject is demonstrated. The results are successfully validated by comparing the outcome to the anatomy by using a single set of high resolution histological sectionings of the region of interest.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Darkner, S. (Intern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
Pages: 801-808
Publication date: 2007

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Title of host publication: Lecture Notes in Computer Science : Medical Image Computing and Computer-Assisted Intervention – MICCAI 2007
Volume: Volume 4792
Place of publication: Berlin / Heidelberg
Publisher: Springer
A path algorithm for the support vector domain description and its application to medical imaging

The support vector domain description is a one-class classification method that estimates the distributional support of a data set. A flexible closed boundary function is used to separate trustworthy data on the inside from outliers on the outside. A single regularization parameter determines the shape of the boundary and the proportion of observations that are regarded as outliers. Picking an appropriate amount of regularization is crucial in most applications but is, for computational reasons, commonly limited to a small collection of parameter values. This paper presents an algorithm where the solutions for all possible values of the regularization parameter are computed at roughly the same computational complexity previously required to obtain a single solution. Such a collection of solutions is known as a regularization path. Knowledge of the entire regularization path not only aids model selection, but may also provide new information about a data set. We illustrate this potential of the method in two applications; one where we establish a sensible ordering among a set of corpora callosa outlines, and one where ischemic segments of the myocardium are detected in patients with acute myocardial infarction.
A Point-Wise Quantification of Asymmetry Using Deformation Fields: Application to the Study of the Crouzon Mouse Model

This paper introduces a novel approach to quantify asymmetry in each point of a surface. The measure is based on analysing displacement vectors resulting from nonrigid image registration. A symmetric atlas, generated from control subjects is registered to a given subject image. A comparison of the resulting displacement vectors on the left and right side of the symmetry plane, gives a point-wise measure of asymmetry. The asymmetry measure was applied to the study of Crouzon syndrome using Micro CT scans of genetically modified mice. Crouzon syndrome is characterised by the premature fusion of cranial sutures, which gives rise to a highly asymmetric growth. Quantification and localisation of this asymmetry is of high value with respect to surgery planning and treatment evaluation. Using the proposed method, asymmetry was calculated in each point of the surface of Crouzon mice and wild-type mice (controls). Asymmetry appeared in similar regions for the two groups but the Crouzon mice were found significantly more asymmetric. The localisation ability of the method was in good agreement with ratings from a clinical expert. Validating the quantification ability is a less trivial task due to the lack of a gold standard. Nevertheless, a comparison with a different, but less accurate measure of asymmetry revealed good correlation.

General information
State: Published
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Series: Lecture Notes in Computer Science
A Statistical Model of Head Asymmetry in Infants with Deformational Plagiocephaly

Deformational plagiocephaly is a term describing cranial asymmetry and deformation commonly seen in infants. The purpose of this work was to develop a methodology for assessment and modelling of head asymmetry. The clinical population consisted of 38 infants for whom 3-dimensional surface scans of the head had been obtained both before and after their helmet orthotic treatment. Non-rigid registration of a symmetric template to each of the scans provided detailed point correspondence between scans. A new asymmetry measure was defined and was used in order to quantify and localize the asymmetry of each infant's head, and again employed to estimate the improvement of asymmetry after the helmet therapy. A statistical model of head asymmetry was developed (PCA). The main modes of variation were in good agreement with clinical observations, and the model provided an excellent and instructive quantitative description of the asymmetry present in the dataset.

Automatic assessment of intrabdominal fat by MRI

Automatic Detection of Wild-type Mouse Cranial Sutures

In the study of craniofacial malformations, the cranial sutures are often of interest. The premature fusion of sutures occurring in e.g. Crouzon and Apert syndrome can lead to asymmetric head shape, enlarged intracranial pressure and blindness. In large population studies of such syndromes, automatic detection of the cranial sutures becomes important. We have previously built a craniofacial, wild-type mouse atlas from a set of 10 Micro CT scans using a B-spline-based nonrigid registration method by Rueckert et al. Subsequently, all volumes were registered nonrigidly to the atlas. Using these transformations, any annotation on the atlas can automatically be transformed back to all cases. For this study, two rounds of tracing seven of the cranial sutures, were performed on the atlas by one observer. The average of the two rounds was automatically propagated to all the cases. For validation, the observer traced the sutures on each of the mouse volumes as well. The observer outperforms the automatic approach by approximately 0.1 mm. All mice have
similar errors while the suture error plots reveal that suture 1 and 2 are cumbersome, both for the observer and the automatic approach. These sutures can be hard to detect with the eye. We still believe that overall, the errors are not considerable and by qualitatively estimating the accuracy, the automatic sutures are very close to the observer sutures. Our plan is to improve the results by local feature detection methods.

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Main Research Area: Technical/natural sciences
Source: orbit
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Classification of Biological Objects Using Active Appearance Modelling and Color Cooccurrence Matrices

General information
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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Dahl, A. B. (Intern), Aanæs, H. (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern)
Pages: 938-947
Publication date: 2007
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Main Research Area: Technical/natural sciences
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Context: The number of CAG-repeats within the CAG-repeat polymorphism of the androgen receptor gene is inversely correlated with the transcriptional activity of the androgen receptor. Objective: To study the effect of the CAG-repeat number and circulating androgens on muscle size, to examine the CAG-repeat number in relation to body fat mass and circulating androgens, and to identify the best hormonal marker of low muscle size amongst total testosterone, bioavailable testosterone, and dihydrotestosterone. Design, Setting, and Participants: Population-based study of 783 Danish men aged 20-29 years, who matched the background population as regards body mass index, chronic disease, medication, physical activity, smoking, and sociodemographic parameters. Genotyping was performed in 767 men, whole body DXA in 783 men, and MRI in 406 consecutively included men. Main Outcome Measures: Six continuous outcomes (thigh and axial muscle area, lower extremity, upper extremity, and trunk lean body mass, and total body fat mass) and five binary outcomes of low muscle size defined as men with muscle size below the lower 10 percentile of each continuous outcome of muscle size. Results: The CAG-repeat number correlated inversely with thigh and axial muscle area and with lower and upper extremity lean body mass. Except for upper extremity lean body mass, these findings remained significant in multivariate analyses controlling for circulating androgens, physical activity, smoking, alcohol intake, chronic disease, and age. The CAG-repeat number correlated positively with total body fat mass adjusted for weight, but not with the concentration of any of the circulating androgens. Total testosterone and dihydrotestosterone correlated positively with all outcomes of muscle size. The prevalence of low muscle size increased exponentially with decreasing androgen levels and was tripled at total testosterone levels

General information
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Publication date: 2007
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Coupled Shape Modeling of the Medial Temporal Lobe

Here we investigate how regions in the Medial Temporal Lobe (MTL) in a dataset consisting of 13 different people change. By using Principal Component Analysis (PCA), the regions investigated are the Temporopolar, Parahippocampal, Entorhinal, Hippocampal, Perirhinal, andAmygdalar regions. The MTL is located fairly deep in the brain where the contrast is quite low, and region-boundaries can be difficult to find, which is why a shape guiding term would be helpful for a segmentation algorithm. An expert used an interactive tool to draw binary (1 inside and 0 outside) Volumes Of Interests (VOI) for each of the 13 subjects. As the brain is symmetric, 12 VOIs has been drawn for each subject. A simultaneous multi-shape rigid registration scheme, similar to the one used in [Tsai et al., 2004] was used on the training shapes to remove linearities. As these are binary shapes, a set-difference cost function is minimized between all shapes. To represent shapes in the coupled shape model, signed distance maps (SDM) were used, [Tsai et al., 2004]. The eigen-problem was solved on the covariance matrix using svd, to find the eigenshapes and their magnitude. Seven modes of variation were extracted, representing 75% of the total variance which each represents different modes of variations. An interactive program was developed to investigate how the first seven modes changes the shapes. In figures 1 to 3 the most significant mode is seen varying with $2\sigma$ from the meanshape. Fig. 1. meanshape + $2\sigma$ Fig. 2. meanshape Fig. 3. meanshape - $2\sigma$

General information
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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
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Craniofacial Statistical Deformation Models of Wild-type mice and Crouzon mice

Crouzon syndrome is characterised by the premature fusion of cranial sutures and synchondroses leading to craniofacial growth disturbances. The gene causing the syndrome was discovered approximately a decade ago and recently the first mouse model of the syndrome was generated. In this study, a set of Micro CT scannings of the heads of wild-type (normal) mice and Crouzon mice were investigated. Statistical deformation models were built to assess the anatomical differences between the groups, as well as the within-group anatomical variation. Following the approach by Rueckert et al., we built an atlas using B-spline-based nonrigid registration and subsequently, the atlas was nonrigidly registered to the cases being modelled. The parameters of these registrations were then used as input to a PCA. Using different sets of registration parameters, different models were constructed to describe (i) the difference between the two groups in anatomical variation and (ii) the within-group variation. These models confirmed many known traits in the wild-type and Crouzon mouse craniofacial anatomy. Moreover, they showed new traits, not reported before.

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Diffeomorphic Statistical Deformation Models
In this paper we present a new method for constructing diffeomorphic statistical deformation models in arbitrary dimensional images with a nonlinear generative model and a linear parameter space. Our deformation model is a modified version of the diffeomorphic model introduced by Cootes et al. The modifications ensure that no boundary restriction has to be enforced on the parameter space to prevent folds or tears in the deformation field. For straightforward statistical analysis, principal component analysis and sparse methods, we assume that the parameters for a class of deformations lie on a linear manifold and that the distance between two deformations are given by the metric introduced by the L2-norm in the parameter space. The chosen L2-norm is shown to have a clear and intuitive interpretation on the usual nonlinear manifold. Our model is validated on a set of MR images of corpus callosum with ground truth in form of manual expert annotations, and compared to Cootes's model. We anticipate applications in unconstrained diffeomorphic synthesis of images, e.g. for tracking, segmentation, registration or classification purposes.

Environmental Effects on Measurement Uncertainties of Time-of-Flight Cameras
In this paper the effect the environment has on the SwissRanger SR3000 Time-Of-Flight camera is investigated. The accuracy of this camera is highly affected by the scene it is pointed at: Such as the reflective properties, color and gloss. Also the complexity of the scene has considerable effects on the accuracy. To mention a few: The angle of the objects to the emitted light and the scattering effects of near objects. In this paper a general overview of known such inaccuracy factors are described, followed by experiments illustrating the additional uncertainty factors. Specifically we give a better description of how a surface color intensity influences the depth measurement, and illustrate how multiple reflections influence the resulting depth measurement.
**Estimation of independent non-linear deformation modes for analysis of craniofacial malformations in Crouzon mice**

Crouzon syndrome is a genetic disease resulting in premature fusion of cranial sutures and synchondroses causing craniosynostosis. A decade ago the Crouzon gene was discovered, and recently the first mouse model of the syndrome was generated. In this study, a set of Micro CT scannings of the heads of wild-type (normal) mice and Crouzon mice were investigated. We present for what we believe is the first time, a statistical deformation model based on independent component analysis (ICA). A set of deformation parameters for each mouse was calculated using a B-spline-based nonrigid registration. From the parameters controlling the deformations for each subject, the statistical model was estimated. ICA is demonstrated to provide localized deformation components, many of which give a clear separation between Crouzon and wild-type mice. This is a clear improvement of a previous principal component-based model, which only provided one global deformation component describing the disease. The ICA components allow interpretation of each deformation feature to be carried out independently of other features, and provides a basis for linking the observed craniofacial malformations to the fusing of sutures. ICA revealed an interesting new finding, not previously reported in the literature, namely asymmetries in the head in Crouzon mice. This phenomenon is probably caused by asymmetric closure of craniofacial sutures.

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**Bibliographical note**

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**Evaluating a method for automated rigid registration**

We evaluate a novel method for fully automated rigid registration of 2D manifolds in 3D space based on distance maps, the Gibbs sampler and Iterated Conditional Modes (ICM). The method is tested against the ICP considered as the gold standard for automated rigid registration. Furthermore, the influence of different norms and sampling point densities is evaluated. The performance of the two methods has been evaluated on data consisting of 178 scanned ear impressions taken from the right ear. To quantify the difference of the two methods we calculate the registration cost and the mean point to point distance. T-test for common mean are used to determine the performance of the two methods (supported by a Wilcoxon signed rank test). The performance influence of sampling density, sampling quantity, and norms is analyzed using a similar method.

**General information**

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**Organisations:** Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling  
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Generative-model based vision

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Pece, A. E. C. (Ekstern), Larsen, R. (Intern)
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Scopus rating (2014): SJR 0.834 SNIP 1.985 CiteScore 2.83
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Scopus rating (2013): SJR 1.102 SNIP 2.631 CiteScore 3.39
ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 0.845 SNIP 2.466 CiteScore 2.91
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Scopus rating (2011): SJR 1.352 SNIP 4.421 CiteScore 4.82
ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 1.412 SNIP 3.775
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.45 SNIP 3.427
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.44 SNIP 2.92
Scopus rating (2007): SJR 1.846 SNIP 3.101
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Scopus rating (2006): SJR 1.497 SNIP 3.104
Scopus rating (2005): SJR 1.187 SNIP 2.696
Improving Face Detection with TOE Cameras

A face detection method based on a boosted classifier using images from a time-of-flight sensor is presented. We show that the performance of face detection can be improved when using both depth and gray scale images and that the common use of integration of hypotheses for verification can be relaxed. Based on the detected face we employ an active contour method on depth images for full head segmentation.

Individual discriminative face recognition models based on subsets of features

The accuracy of data classification methods depends considerably on the data representation and on the selected features. In this work, the elastic net model selection is used to identify meaningful and important features in face recognition. Modelling the characteristics which distinguish one person from another using only subsets of features will both decrease the computational cost and increase the generalization capacity of the face recognition algorithm. Moreover, identifying which are the features that better discriminate between persons will also provide a deeper understanding of the face recognition problem. The elastic net model is able to select a subset of features with low computational effort compared to other state-of-the-art feature selection methods. Furthermore, the fact that the number of features usually is larger than the number of images in the data base makes feature selection techniques such as forward selection or lasso regression become inadequate. In the experimental section, the performance of the elastic net model is compared with geometrical and color based algorithms widely used in face recognition such as Procrustes nearest neighbor, Eigenfaces, or Fisher-faces. Results show that the elastic net is capable of selecting a set of discriminative features and thereby obtain higher classification rates.
Ischemic Segment Detection using the Support Vector Domain Description

Myocardial perfusion Magnetic Resonance (MR) imaging has proven to be a powerful method to assess coronary artery diseases. The current work presents a novel approach to the analysis of registered sequences of myocardial perfusion MR images. A previously reported AAM-based segmentation and registration of the myocardium provided pixel-wise signal intensity curves that were analyzed using the Support Vector Domain Description (SVDD). In contrast to normal SVDD, the entire regularization path was calculated and used to calculate a generalized distance. The results corresponded well to the ischemic segments found by assessment of the three common perfusion parameters; maximum upslope, peak and time-to-peak obtained pixel-wise.
Mahalanobis Distance Based Iterative Closest Point

This paper proposes an extension to the standard iterative closest point method (ICP). In contrast to ICP, our approach (ICP-M) uses the Mahalanobis distance to align a set of shapes thus assigning an anisotropic independent Gaussian noise to each point in the reference shape. The paper introduces the notion of a mahalanobis distance map upon a point set with associated covariance matrices which in addition to providing correlation weighted distance implicitly provides a method for assigning correspondence during alignment. This distance map provides an easy formulation of the ICP problem that permits a fast optimization. Initially, the covariance matrices are set to the identity matrix, and all shapes are aligned to a randomly selected shape (equivalent to standard ICP). From this point the algorithm iterates between the steps: (a) obtain mean shape and new estimates of the covariance matrices from the aligned shapes, (b) align shapes to the mean shape. Three different methods for estimating the mean shape with associated covariance matrices are explored in the paper. The proposed methods are validated experimentally on two separate datasets (IMM face dataset and femur-bones). The superiority of ICP-M compared with ICP in recovering the underlying correspondences in the face dataset is demonstrated.

Multiple Geodesic Distance Based Registration of Surfaces Applied to Facial Expression Data

Quantifying Biological Variation
Robust Pose Estimation using the SwissRanger SR-3000 Camera

In this paper a robust method is presented to classify and estimate an object's pose from a real-time range image and a low-dimensional model. The model is made from a range image training set which is reduced dimensionally by a nonlinear manifold learning method named Local Linear Embedding (LLE). New range images are then projected to this model giving the low-dimensional coordinates of the object pose in an efficient manner. The range images are acquired by a state-of-the-art SwissRanger SR-3000 camera making the projection process work in real-time.

Robust Pseudo-Hierarchical Support Vector Clustering

Support vector clustering (SVC) has proven an efficient algorithm for clustering of noisy and high-dimensional data sets, with applications within many fields of research. An inherent problem, however, has been setting the parameters of the SVC algorithm. Using the recent emergence of a method for calculating the entire regularization path of the support vector domain description, we propose a fast method for robust pseudo-hierarchical support vector clustering (HSVC). The method is demonstrated to work well on generated data, as well as for detecting ischemic segments from multidimensional myocardial perfusion magnetic resonance imaging data, giving robust results while drastically reducing the need for parameter estimation.
Sparse Decomposition and Modeling of Anatomical Shape Variation

Recent advances in statistics have spawned powerful methods for regression and data decomposition that promote sparsity, a property that facilitates interpretation of the results. Sparse models use a small subset of the available variables and may perform as well or better than their full counterparts if constructed carefully. In most medical applications, models are required to have both good statistical performance and a relevant clinical interpretation to be of value. Morphometry of the corpus callosum is one illustrative example. This paper presents a method for relating spatial features to clinical outcome data. A set of parsimonious variables is extracted using sparse principal component analysis, producing simple yet characteristic features. The relation of these variables with clinical data is then established using a regression model. The result may be visualized as patterns of anatomical variation related to clinical outcome. In the present application, landmark-based shape data of the corpus callosum is analyzed in relation to age, gender, and clinical tests of walking speed and verbal fluency. To put the data-driven sparse principal component method into perspective, we consider two alternative techniques, one where features are derived using a model-based wavelet approach, and one where the original variables are regressed directly on the outcome.

General information
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Pages: 1625-1635
Publication date: 2007
Main Research Area: Technical/natural sciences
Sparse Statistical Deformation Model for the Analysis of Craniofacial Malformations in the Crouzon Mouse

Crouzon syndrome is characterised by the premature fusion of cranial sutures. Recently the first genetic Crouzon mouse model was generated. In this study, Micro CT skull scannings of wild-type mice and Crouzon mice were investigated. Using nonrigid registration, a wild-type mouse atlas was built. The atlas was registered to all mice providing parameters controlling the deformations for each subject. Our previous PCA-based statistical deformation model on these parameters revealed only one discriminating mode of variation. Aiming at distributing the discriminating variation over more modes we built a different model using Independent Component Analysis (ICA). Here, we focus on a third method, sparse PCA (SPCA), which aims at approximating the properties of a standard PCA while introducing sparse modes of variation. This approach is compared to a standard PCA and ICA. The results show that the SPCA outperforms both ICA and PCA with respect to the Fisher discriminant.
Surface-to-surface registration using level sets

This paper presents a general approach for surface-to-surface registration (S2SR) with the Euclidean metric using signed distance maps. In addition, the method is symmetric such that the registration of a shape A to a shape B is identical to the registration of the shape B to the shape A. The S2SR problem can be approximated by the image registration (IR) problem of the signed distance maps (SDMs) of the surfaces confined to some narrow band. By shrinking the narrow bands around the zero level sets the solution to the IR problem converges towards the S2SR problem. It is our hypothesis that this approach is more robust and prone to fall into local minima than ordinary surface-to-surface registration. The IR problem is solved using the inverse compositional algorithm. In this paper, a set of 40 pelvic bones of Duroc pigs are registered to each other w.r.t. the Euclidean transformation with both the S2SR approach and iterative closest point approach, and the results are compared.

Texture Enhanced Appearance Models

Statistical region-based registration methods such as the Active Appearance Model (AAM) are used for establishing dense correspondences in images. At low resolution, images correspondences can be recovered reliably in real-time. However, as resolution increases this becomes infeasible due to excessive storage and computational requirements. We propose to reduce the dimensionality of the textural components by selecting a subset of basis functions from a larger dictionary, estimate regression splines and model only the coefficients of the retained basis functions. We demonstrate the use of two types of bases, namely wavelets and wedgelets. The former extends the previous work of Wolstenholme and Taylor where Haar wavelet coefficients subsets were applied. The latter introduces the wedgelet regression tree based on triangulated domains. The wavelet and wedgelet regression splines are functional descriptions of the intensity information and serve to 1) reduce noise and 2) produce a compact textural description. Dimensionality reduction by subsampling in the CDF 9-7 wavelet and wedgelet representations yield better results than ‘standard’ subsampling in the pixel domain. We show that the bi-orthogonal CDF 9-7 wavelet yields better results than the Haar wavelet. Further, we show that the inherent frequency separation in wavelets allows for cost-free band-pass filtering, e.g. edge-emphasis, and that this edge enhancement provide better results in terms of segmentation accuracy. Wedgelet representation are superior to wavelet representations at high dimensionality-reduction rates. At low reduction rates an edge enhanced wavelet representation provides better segmentation accuracy than the full standard AAM model.
wedgelets, atlases, wavelets, deformable models, face images, registration, active appearance models, dimensionality reduction

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Context: No large studies have examined the relation between circulating androgen levels and regional, abdominal adiposity in young men using magnetic resonance imaging (MRI). Objective: To study the role of visceral and subcutaneous adipose tissue (VAT and SAT) on circulating androgens and to examine the impact of obesity on androgen reference-intervals. Design, Setting, and Participants: Population-based study of 783 Danish, 20-29 year-old men. Ninety-eight men were ruled out of the healthy reference-population by predefined criteria related with hypogonadism. Total, central, and lower extremity fat mass (TFM, CFM, and LEFM) were assessed in all men by DXA and MRI was performed in 406 men. Main Outcome Measures: Total, bioavailable, and free testosterone (TT, BT, and FT), androstenedione (Δ4AD), dihydrotestosterone (DHT), estradiol (E2), 2/TT-ratio, sex hormone-binding globulin (SHBG), and luteinizing hormone (LH). Results: Significant, inverse, linear relationships were observed between TT, BT, FT, DHT, SHBG and all DXA measures, whereas a positive correlation was found for E2/TT-ratio. No associations were found for Δ4AD. Independent, inverse relations between CFM and TT (p...
3D Face Appearance Model

We build a 3D face shape model, including inter- and intra-shape variations, derive the analytical Jacobian of its resulting 2D rendered image, and show example of its fitting performance with light, pose, id, expression and texture variations.

An Adipose Segmentation and Quantification Scheme for the Abdominal Region in Minipigs

Bibliographical note
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Contextual Analysis of CT Scanned Pig Carcasses

Knowledge of the weight of tissue types in pig carcasses is generally only available after manual dissection. The use of computed tomography (CT) has demonstrated to be a promising approach to gain knowledge on the lean meat weight (Romvari, 2005), but less effort has been put into gaining knowledge about the weight of other tissue types from CT.
Knowing the weight of individual tissue types will directly give access to other measures such as the weight of the carcass and the Lean Meat Percentage (LMP). Until now, most analyses of CT scans have been based on the Hounsfield spectra that does not consider the spatial context in CT scan. Applying contextual methods from the field of image analysis we hope to make a virtual dissection of pig carcasses.

**General information**
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Organisations: Metal Structures in Four Dimensions, Materials Research Division, Risø National Laboratory for Sustainable Energy, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Department of Photonics Engineering
Authors: Lyckegaard, A. (Intern), Larsen, R. (Intern), Christensen, L. B. (Intern), Vester-Christensen, M. (Intern), Olsen, E. V. (Ekstern)
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**Corpus Callosum Partitioning Schemes and Their Effect on Callosal Morphometry**

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Ryberg, C. (Ekstern), Stegmann, M. B. (Intern), Sjöstrand, K. (Intern), Rostrup, E. (Ekstern), Barkhof, F. (Ekstern), Fazekas, F. (Ekstern), Waldemar, G. (Ekstern)
Publication date: 2006

**Host publication information**
Publisher: ISMRM
Main Research Area: Technical/natural sciences
Conference: 14th Scientific Meeting and Exhibition of International Society for Magnetic Resonance in Medicine, Seattle, WA, United States, 06/05/2006 - 06/05/2006
Electronic versions:
imm4410.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4410
Source: orbit
Source-ID: 191594
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

**Coupled Shape Model Segmentation in Pig Carcasses**
In this paper we are concerned with multi-object segmentation. For each object we will train a level set function based shape prior from a sample set of outlines. The outlines are aligned in a multi-resolution scheme wrt. an Euclidean similarity transformation in order to maximize the overlap of the interior between all pairs of outlines. Then the outlines are converted to level set functions. A shape model is constructed from the mean level set and the first few principal variations. We combine the prior model with an observation model based on the Chan-Vese functional assuming constant intensity levels inside the outline as well as in a narrow band outside the outline. The maximum a posteriori estimate of the outline is found by gradient descent optimization. In order to segment a group of mutually dependent objects we propose 2 procedures, 1) the objects are found sequentially by conditioning the initialization of the next search from already found objects; 2) all objects are found simultaneously and a repelling force is introduced in order to avoid overlap between outlines in the solution. The methods are applied to segmentation of cross sections of muscles in slices of CT scans of pig backs for quality assessment of bacon slices.
On the Alignment of Shapes Represented by Fourier Descriptors

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Sjöstrand, K. (Intern), Ericsson, A. (Ekstern), Larsen, R. (Intern)
Publication date: 2006

Host publication information
Title of host publication: International Symposium on Medical Imaging 2006, San Diego, CA, USA
Publisher: The International Society for Optical Engineering (SPIE)
Main Research Area: Technical/natural sciences
Electronic versions:
imm4045.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4045
Source: orbit
Source-ID: 191574
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Registration and shape modelling of porcine bone structures via CT

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Erbou, S. G. (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern)
Publication date: 2006

Host publication information
Title of host publication: 21st Nordic Conference on Mathematical Statistics
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Main Research Area: Technical/natural sciences
Electronic versions:
imm4862.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4862
Source: orbit
Source-ID: 191587
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Sparse Modelling of Landmark and Texture Variability using the Orthomax Criterion

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Stegmann, M. B. (Intern), Sjöstrand, K. (Intern), Larsen, R. (Intern)
Sparse PCA, a new method for unsupervised analyses of fMRI data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Sjöstrand, K. (Intern), Lund, T. E. (Ekstern), Madsen, K. H. (Intern), Larsen, R. (Intern)
Publication date: 2006

Host publication information
Publisher: ISMRM
Main Research Area: Technical/natural sciences
Conference: 14th Scientific Meeting and Exhibition of International Society for Magnetic Resonance in Medicine, Seattle, WA, United States, 06/05/2006 - 06/05/2006
Electronic versions:
imm4407.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4407
Source: orbit
Source-ID: 191595
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Sparse Principal Component Analysis in Medical Shape Modeling

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Sjöstrand, K. (Intern), Stegmann, M. B. (Intern), Larsen, R. (Intern)
Publication date: 2006

Host publication information
Title of host publication: International Symposium on Medical Imaging 2006, San Diego, CA, USA
Publisher: The International Society for Optical Engineering (SPIE)
Main Research Area: Technical/natural sciences
Electronic versions:
imm4042.pdf
Links:
Source: orbit
Source-ID: 191573
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

The entire regularization path for the support vector domain description

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Sjöstrand, K. (Intern), Larsen, R. (Intern)
A face recognition algorithm based on multiple individual discriminative models

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Fagertun, J. (Intern), Gomez, D. D. (Intern), Erbsøll, B. K. (Intern), Larsen, R. (Intern)
Pages: 69-75
Publication date: 2005

Host publication information
Title of host publication: Dansk Selskab for Genkendelse af Mønstre (Danish Pattern Recognition Society) DSAGM 2005
Publisher: Department of Computer Science, University of Copenhagen (DIKU)
Main Research Area: Technical/natural sciences
Conference: Dansk Selskab for Genkendelse af Mønstre (Danish Pattern Recognition Society) DSAGM 2005, 01/01/2005
Electronic versions:
imm4007.pdf
Links:
http://www.diku.dk/dsagm2005/
Source-ID: 185771
Publication: Research › Article in proceedings – Annual report year: 2005

Functional 2D Procrustes Shape Analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern)
Publication date: 2005

Host publication information
Title of host publication: 14th Scandinavian Conference on Image Analysis
Publisher: Springer Verlag
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3882
Source-ID: 185710
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Functional Maximum Autocorrelation Factors

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern)
Publication date: 2005
Non-linear Shape Decomposition using ISOMAP

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern)
Publication date: 2005

Statistical Shape Analysis of the Human Ear Canal with Application to In-the-Ear Hearing Aid Design

This thesis is about the statistical shape analysis of the human ear canal with application to the mechanical design of in-the-ear hearing aids. Initially, it is described how a statistical shape model of the human ear canal is built based on a training set of laser-scanned ear impressions. A thin plate spline based approach creates a dense correspondence between the shapes in training set. In addition, a new flexible, non-rigid registration framework is proposed and used to optimise the correspondence. The framework is based on Markov Random Field regularisation and is motivated by prior work on image restoration. It is shown how the method significantly improves the shape model. In the second part of the thesis, the shape model is used in software tools that mimic the skills of the expert hearing aid makers. The first result is that it is possible to learn an algorithm to cut an ear canal in order to produce an optimal in-the-ear hearing aid.

Secondly, a framework for component placement using a coupling of stochastic optimisation and the results from the shape model is proposed. It is successfully, used to place the so-called faceplate with associated component on in-the-ear hearing aids. In addition, the idea of one-size-fits-most shells is explored. In Danish: Denne afhandling beskriver brugen af statistisk formanalyse af den menneskelige hørekanal i det mekaniske design af i-øret høreapparater. Først beskrives det hvordan en statistisk formmodel af den menneskelige øre-kanal er lavet på baggrund af et træningsæt af laser-skannede øre aftryk. En Thin Plate Spline baseret metode genererer en kompakt korrespondance mellem formerne i træningsættet. Endvidere er en fleksibel, ikke-rigid registrerings metode foreslået og brugt til at optimere korrespondance feltet. Metoden er baseret på Markov Random Field regulering og er motiveret af tidligere arbejde vedrørende bilede opretning. Det er vist hvordan metoden signifikant forbedrer formmodellen. I den anden del af afhandlingen, bruges formmodellen i programmer, der efterligner evnerne hos de bedste af dem der laver høreapparater. Det første resultat er, at det er muligt at lære en algoritme at skære en ørekanal for at producere et optimalt i-øret høreapparat. Derudover er ideen om en skal af en størrelse og form, som passer de fleste foruligt.
Generative Interpretation of Medical Images

This thesis describes, proposes and evaluates methods for automated analysis and quantification of medical images. A common theme is the usage of generative methods, which draw inference from unknown images by synthesising new images having shape, pose and appearance similar to the analysed images. The theoretical framework for fulfilling these goals is based on the class of Active Appearance Models, which has been explored and extended in case studies involving cardiac and brain magnetic resonance images (MRI), and chest radiographs. Topics treated include model truncation, model compression using wavelets, handling of non-Gaussian variation by means of cluster analysis, correction of respiratory noise in cardiac MRI, and the extensions to multi-slice two-dimensional time-series and bi-temporal three-dimensional models. The medical applications include automated estimation of: left ventricular ejection fraction from 4D cardiac cine MRI, myocardial perfusion in bolus passage cardiac perfusion MRI, corpus callosum shape and area in mid-sagittal brain MRI, and finally, lung, heart, clavicle location and cardiothoracic ratio in anterior-posterior chest radiographs.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, DTU Data Analysis
Authors: Stegmann, M. B. (Intern), Ersbøll, B. K. (Intern), Larsen, R. (Intern)
Publication date: Jun 2004

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Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm3126.pdf
Links:
Source: orbit
Source-ID: 154836
Publication: Research › Ph.D. thesis – Annual report year: 2004

Markov Random Field Restoration of Point Correspondences for Active Shape Modelling

In this paper it is described how to build a statistical shape model using a training set with a sparse of landmarks. A well defined model mesh is selected and fitted to all shapes in the training set using thin plate spline warping. This is followed by a projection of the points of the warped model mesh to the target shapes. When this is done by a nearest neighbour projection it can result in folds and inhomogeneities in the correspondence vector field. The novelty in this paper is the use and extension of a Markov random field regularisation of the correspondence field. The correspondence field is regarded as a collection of random variables, and using the Hammersley-Clifford theorem it is proved that it can be treated as a Markov Random Field. The problem of finding the optimal correspondence field is cast into a Bayesian framework for Markov Random Field restoration, where the prior distribution is a smoothness term and the observation model is the curvature of the shapes. The Markov Random Field is optimised using a combination of Gibbs sampling and the Metropolis-Hasting algorithm. The parameters of the model is found using a leave-one-out approach. The method leads to a generative model that produces highly homogeneous polygonised shapes with improved reconstruction capabilities of the training data. Furthermore, the method leads to an overall reduction in the total variance of the resulting point distribution model. The method is demonstrated on a set of human ear canals extracted from 3D-laser scans.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Hilger, K. B. (Intern), Paulsen, R. R. (Intern), Larsen, R. (Intern)
Publication date: 2004

Host publication information
Title of host publication: SPIE - Medical Imaging
Main Research Area: Technical/natural sciences
Conference: SPIE - Medical Imaging, San Diego, United States, 14/02/2004 - 14/02/2004
Links:
Proceedings of the Second International workshop on Generative-Model Based Vision

In the last decade, there has been a convergence of statistical and model-based approaches to computational vision. This is an ongoing process, leading to the emerging paradigm of generative-model-based (GMB) vision. This workshop/special issue aims to bring together researchers working on different problems within computational vision, who are interested in this paradigm. For the purposes of the workshop/special issue, GMB vision is a methodology which prescribes * the formulation of a parameterized probabilistic model of image generation; * estimation and/or maximization of the posterior probability (given an image or image sequence) of model parameters (state variables). Often, the generative model is used not only by the software developer in the formulation of the algorithm, but also by the algorithm itself as a component of an iterative estimation process. The state variables are whatever people want to know, (e.g. position, size, shape, color) about objects of interest. This definition is not meant to be dogmatic or to inhibit the development of the field, but only to give a focus to the presentations. In addition to papers describing new GMB algorithms, also appropriate to the workshop/special issue are * papers which focus on a detailed study of generative models (e.g. as models of the statistics of natural images); * papers which present new estimation methods for model parameters, or compare different estimation methods applied to the same generative model; * papers providing a GMB interpretation (or modification) of established vision algorithms. Examples of topics relevant to the workshop/special issue include, but are by no means limited to, the topics covered in the first GMBV workshop.

Unsupervised Correction of Physiologically-induced Slice-offsets in 4D Cardiac MRI

Using a Shape Model in the Design of Hearing Aids

Today the design of custom completely-in-the-canal hearing aids is a manual process and therefore there is a variation in the quality of the finished hearing aids. Especially the placement of the so-called faceplate on the hearing aid strongly influences the size and shape of the hearing aid. Since the future hearing aid production will be less manual there is a need for algorithms that mimic the craftsmanship of skilled operators. In this paper it is described how a statistical shape model of the ear canal can be used to predict the placement of the faceplate on a hearing aid made for a given ear canal. The shape model is a point distribution model built using a training set of shapes with manually placed landmarks. An
interpolation method is used to generate dense landmark correspondence over the training set prior to building the shape model. Faceplates have also been placed on the training shapes by a skilled operator. These faceplate planes are aligned to the average shape from the shape model and an average faceplate plane is calculated. Given a surface representation of a new ear canal, the shape model is fitted using a combination of the iterative closest point algorithm and the active shape model approach. The average faceplate from the training set can now be placed on the new ear canal using the position of the fitted shape model. A leave-one-out study shows that the algorithm is able to produce results comparable to a human operator.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Oticon A/S
Authors: Paulsen, R. R. (Intern), Nielsen, C. (Ekstern), Laugesen, S. (Ekstern), Larsen, R. (Intern)
Publication date: 2004

Host publication information
Title of host publication: SPIE - Medical Imaging
Main Research Area: Technical/natural sciences
Conference: SPIE - Medical Imaging, San Diego, United States, 12/02/2005 - 12/02/2005
Source: orbit
Source-ID: 154656
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Wedgelet Enhanced Appearance Models
Statistical region-based segmentation methods such as the Active Appearance Model (AAM) are used for establishing dense correspondences in images based on learning the variation in shape and pixel intensities in a training set. For low resolution 2D images correspondences can be recovered reliably in real-time. However, as resolution increases this becomes infeasible due to excessive storage and computational requirements. In this paper we propose to reduce the textural components by modelling the coefficients of a wedgelet based regression tree instead of the original pixel intensities. The wedgelet regression trees employed are based on triangular domains and estimated using cross validation. The wedgelet regression trees are functional descriptions of the intensity information and serve to 1) reduce noise and 2) produce a compact textural description. The wedgelet enhanced appearance model is applied to a case study of human faces. Compression rates of the texture information of 1:40 is obtained without sacrificing segmentation accuracy noticeably, even at compression rates of 1:150 fair segmentation is achieved.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Darkner, S. (Intern), Larsen, R. (Intern), Stegmann, M. B. (Intern), Ersbøll, B. K. (Intern)
Publication date: 2004

Host publication information
Title of host publication: 2nd International Workshop on Generative Model Based Vision (GMBV 2004), Washington, D. C., July, 2nd
Main Research Area: Technical/natural sciences
Conference: 2nd International Workshop on Generative Model Based Vision, washington, D.C., 01/01/2004
Electronic versions: imm3134.pdf
Source: orbit
Source-ID: 154607
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Methods for Structure from Motion
Structure from motion, the problem of estimating 3D structure from 2D images hereof, is one of the most popular and well studied problems within computer vision. In part because it is academically interesting, but also because it holds a wealth of commercially very interesting prospects, e.g. within entertainment, reverse engineering and architecture. This thesis is a study within this area of structure from motion. The result of the work, which this thesis represents is the development of new methods for addressing some of the problems within the field. Mainly in robustifying the factorization approach, relaxing the rigidity constrains, and in considering alternative ways of solving the surface estimation problem. In Danish: Structure from motion problematikken beskæftiger sig med at estimere 3D struktur fra 2D afbilledninger heraf. Denne
problemstilling er en af de mest populære og velstuderede inden for computer vision. Dette skyldes tildels, at den er akademisk interessant, men også at den har et stort kommercielt potentielle. Denne afhandling er rapporteringen af et studie inden for dette område, structure from motion. Dette studie har resulteret i udviklingen af nye metoder til at imødekomme nogle af de problemer, der er inden for området. Hovedsagligt drejer dette sig om at gøre de såkaldte faktoriserings metoder mere robuste, at undersøge hvorledes stivheds antagelsen kan blødes op samt at undersøge alternative måder at løse overflade-estimerings-problemet på.

Active Shape Analysis of Mandibular Growth
This work contains a clinical validation using biological landmarks of a Geometry Constrained Diffusion registration of mandibular surfaces. Canonical Correlations Analysis is extended to analyse 3D landmarks and the correlations are used as similarity measures for landmark clustering. A novel Active Shape Model is proposed targeting growth modelling by applying Partial Least Squares regression in decomposing the Procrustes tangent space. Shape centroid size is applied as dependent variable but the method generalizes to handle other, both uni- and multivariate, effects probing for high covariation wrt. shape variation.

Building a 3-D Appearance Model of the Human Face
This work contains a clinical validation using biological landmarks of a Geometry Constrained Diffusion registration of mandibular surfaces. Canonical Correlations Analysis is extended to analyse 3D landmarks and the correlations are used as similarity measures for landmark clustering. A novel Active Shape Model is proposed targeting growth modelling by applying Partial Least Squares regression in decomposing the Procrustes tangent space. Shape centroid size is applied as dependent variable but the method generalizes to handle other, both uni- and multivariate, effects probing for high covariation wrt. shape variation.
FAME - A Flexible Appearance Modelling Environment

Combined modelling of pixel intensities and shape has proven to be a very robust and widely applicable approach to interpret images. As such the Active Appearance Model (AAM) framework has been applied to a wide variety of problems within medical image analysis. This paper summarises AAM applications within medicine and describes a public domain implementation, namely the Flexible Appearance Modelling Environment (FAME). We give guidelines for the use of this research platform, and show that the optimisation techniques used renders it applicable to interactive medical applications. To increase performance and make models generalise better, we apply parallel analysis to obtain automatic and objective model truncation. Further, two different AAM training methods are compared along with a reference case study carried out on cross-sectional short-axis cardiac magnetic resonance images and face images. Source code and annotated data sets needed to reproduce the results are put in the public domain for further investigation.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Stegmann, M. B. (Intern), Ersbøll, B. K. (Intern), Larsen, R. (Intern)
Pages: 1319 - 1331
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Medical Imaging
Volume: 22
Issue number: 10
ISSN (Print): 0278-0062
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 1.522 SNIP 2.369 CiteScore 4.83
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.765 SNIP 2.68 CiteScore 4.9
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.407 SNIP 2.756 CiteScore 4.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.916 SNIP 3.2 CiteScore 5.55
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.545 SNIP 2.794 CiteScore 4.94
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.332 SNIP 2.583 CiteScore 4.59
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.343 SNIP 2.619
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.371 SNIP 3.352
Growth Modeling of Human Mandibles using Non-Euclidean Metrics

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Hilger, K. B. (Intern), Larsen, R. (Intern), Wrobel, M. (Intern)
Pages: 425-433
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Medical Image Analysis
Volume: 7
Issue number: 4
ISSN (Print): 1361-8415
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 1.948 SNIP 2.838 CiteScore 5.69
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.858 SNIP 3.207 CiteScore 5.61
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.505 SNIP 3.277 CiteScore 5.32
Multi-band Modelling of Appearance

Earlier work has demonstrated generative models capable of synthesising near photo-realistic grey-scale images of objects. These models have been augmented with colour information, and recently with edge information. This paper extends the active appearance model framework by modelling the appearance of both derived feature bands and an intensity band. As a special case of feature-band augmented appearance modelling we propose a dedicated representation with applications to face segmentation. The representation addresses a major problem within face recognition by lowering the sensitivity to lighting conditions. Results show that the localisation accuracy of facial features is considerably increased using this appearance representation under diffuse and directional lighting and at multiple scales.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Stegmann, M. B. (Intern), Larsen, R. (Intern)
Pages: 61-67
Publication date: 2003
Conference: 1st International Workshop on Generative-Model-Based Vision, Copenhagen, Denmark, 02/06/2002
Main Research Area: Technical/natural sciences
PDE Based Surface Estimation for Structure from Motion.
Probabilistic Generative Modelling

This paper illustrates current research at Informatics and Mathematical Modelling at the Technical University of Denmark within biological shape modelling. We illustrate a series of generalizations to, modifications to, and applications of the elements of constructing models of shape or appearance. These elements are correspondence analysis, analysis and decomposition of variability, alignment, and visualisation.

Some Issues of Biological Shape Modelling with Applications

This paper illustrates current research at Informatics and Mathematical Modelling at the Technical University of Denmark within biological shape modelling. We illustrate a series of generalizations to, modifications to, and applications of the elements of constructing models of shape or appearance. These elements are correspondence analysis, analysis and decomposition of variability, alignment, and visualisation.
Statistical shape analysis using non-Euclidean metrics

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Hilger, K. B. (Intern)
Pages: 417-423
Publication date: 2003
Main Research Area: Technical/natural sciences

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Journal: Medical Image Analysis
Volume: 7
Issue number: 4
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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): SJR 1.948 SNIP 2.838 CiteScore 5.69
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.858 SNIP 3.207 CiteScore 5.61
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.505 SNIP 3.277 CiteScore 5.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.782 SNIP 3.533 CiteScore 5.61
ISI indexed (2013): ISI indexed yes
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
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.191 SNIP 2.993
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.32 SNIP 2.551
Scopus rating (2007): SJR 1.845 SNIP 3.064
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.391 SNIP 2.152
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.398 SNIP 3.061
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.543 SNIP 3.17
Scopus rating (2003): SJR 2.488 SNIP 3.457
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.54 SNIP 2.671
**Wedgelet Compression for Appearance Models**

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Darkner, S. (Intern), Larsen, R. (Intern)
Publication date: 2003

**Host publication information**

Title of host publication: Proceedings of the 12th Danish Conference on Pattern Recognition and Image Analysis (DANKOMB, DSAGM), August 21-21
Publisher: Department of Computer Science, University of Copenhagen (DIKU)
Editor: Olsen, S. I.
Main Research Area: Technical/natural sciences
Conference: Proceedings of the 12th Danish Conference on Pattern Recognition and Image Analysis (DANKOMB, DSAGM), August 21-21, 01/01/2003

**A Noise Robust Statistical Texture Model**

This paper presents a novel approach to the problem of obtaining a low dimensional representation of texture (pixel intensity) variation present in a training set after alignment using a Generalised Procrustes analysis. We extend the conventional analysis of training textures in the Active Appearance Models segmentation framework. This is accomplished by augmenting the model with an estimate of the covariance of the noise present in the training data. This results in a more compact model maximising the signal-to-noise ratio, thus favouring subspaces rich on signal, but low on noise. Differences in the methods are illustrated on a set of left cardiac ventricles obtained using magnetic resonance imaging.

**General information**

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Hilger, K. B. (Intern), Stegmann, M. B. (Intern), Larsen, R. (Intern), Dohi, T. (ed.) (Ekstern)
Pages: 444-451
Publication date: 2002
Deteccion de polipos en colonografias virtuales

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Navarro, E. B. (Ekstern), Larsen, R. (Intern), Ersbøll, B. K. (Intern), Arnesen, R. (Ekstern)
Publication date: 2002

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Title of host publication: CASEIB'02 -- XX Congreso Anual de la Sociedad Espanola de la Ingenieria Biomedica, 27-29 November
Publisher: Instituto de investigacion en Ingenieria de Aragon
Main Research Area: Technical/natural sciences
Electronic versions:

Source: orbit
Source-ID: 58245
Publication: Research › Article in proceedings – Annual report year: 2002
L1 Generalized Procrustes 2D Shape Alignment

We describe a new method for resistant and robust alignment of sets of 2D shapes wrt. position, rotation, and isotropical scaling based on minimization of absolute distances. The shapes are represented by \( k \) landmarks in two dimensions. It is formulated as a linear programming (LP) problem, thus enabling the use of wellknown and thoroughly tested standard numerical software. This is achieved by using the city block distance between points in the plane. However, the city block distance is dependent on the orientation of the coordinate system. By simultaneously minimizing the city block distances in a series of rotated coordinate systems we are able to approximate the circular equidistance curves of Euclidean distances with a regular polygonal equidistance curve to the precision needed. Using 3 coordinate systems rotated \( 30^\circ \) we get a 12 sided regular polygon, with which we achieve deviations from Euclidean distances less than 2 \( \% \) over all directions. This new formulation allows for minimization in the \( L_1 \)-norm using LP. We demonstrate that the use of the \( L_1 \)-norm results in resistance towards object as well as landmark outliers. Examples that illustrate the properties of the robust norm are given on simulated as well as medical datasets.

Linear and Nonlinear Multiset Canonical Correlation Analysis (invited talk)

This paper deals with decomposing of multiset data. Friedman's alternating conditional expectations (ACE) algorithm is extended to handle multiple sets of variables of different mixtures. The new algorithm finds estimates of the optimal transformations of the involved variables that maximize the sum of the pair-wise correlations over all sets. The new algorithm is termed multi-set ACE (MACE) and can find multiple orthogonal eigensolutions. MACE is a generalization of the linear multiset correlations analysis (MCCA). It handles multivariate multisets of arbitrary mixtures of both continuous and categorical variables by applying only bivariate scatterplot smoothers for which the data analyst may specify appropriate restrictions when performing an exploratory analysis of the data.
Multi-band Modelling of Appearance
Earlier work has demonstrated generative models capable of synthesising near photo-realistic grey-scale images of objects. These models have been augmented with colour information, and recently with edge information. This paper extends the Active Appearance Model framework by modelling the appearance of both derived feature bands and an intensity band. As a special case of feature-band augmented appearance modelling we propose a dedicated representation with applications to face segmentation. The representation addresses a major problem within face recognition by lowering the sensitivity to lighting conditions. Results show that localisation accuracy of facial features is considerably increased using this appearance representation under normal and abnormal lighting and at multiple scales.
Statistical 2D and 3D shape analysis using Non-Euclidean Metrics
We address the problem of extracting meaningful, uncorrelated biological modes of variation from tangent space shape coordinates in 2D and 3D using non-Euclidean metrics. We adapt the maximum autocorrelation factor analysis and the minimum noise fraction transform to shape decomposition. Furthermore, we study metrics based on repeated annotations of a training set. We define a way of assessing the correlation between landmarks contrary to landmark coordinates. Finally, we apply the proposed methods to a 2D data set consisting of outlines of lungs and a 3D/(4D) data set consisting of sets of mandible surfaces. In the latter case the end goal is to construct a model for growth prediction and simulation.

Testing for Gender Related Size and Shape Differences of the Human Ear canal using Statistical methods
This work deals with the analysis of the shape of the human ear canal. It is described how a dense surface point distribution model of the human ear canal is built based on a training set of laser scanned ear impressions and a sparse set of anatomical landmarks placed by an expert. The dense surface models are built by using the anatomical landmarks to warp a template mesh onto all shapes in the training set. Testing the gender related differences is done by initially reducing the dimensionality using principal component analysis of the vertices of the warped meshes. The number of components to retain is chosen using Horn's parallel analysis. Finally a multivariate analysis of variance is performed on these components.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Technical University of Denmark
Authors: Paulsen, R. R. (Intern), Larsen, R. (Intern), Ersbøll, B. K. (Intern), Nielsen, C. (Ekstern), Laugesen, S. (Intern), Conradsen, K. (ed.) (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: Eleventh International Workshop on Matrices and Statistics
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Main Research Area: Technical/natural sciences
Conference: Eleventh International Workshop on Matrices and Statistics, 01/01/2002
Links:
A Scheme for Initial Exploratory Data Analysis of Multivariate Image Data
A new scheme is proposed for handling initial exploratory analyses of multivariate image data. The method is invariant to linear transformations of the original data and is useful for data fusion of multisource measurements. The scheme includes dimensionality reduction followed by unsupervised clustering of the data. A transformation is proposed which maximizes autocorrelation by projection onto subspaces with signal-to-noise ratio dependent variance. We apply the traditional fuzzy c-means algorithm and introduce two additional memberships enhancing the textural awareness of the algorithm. Cluster validation is performed by examining the partition density of the segmentations as a function of the number of classes applied. Results are presented for a synthetic 2-band noise degenerated image and for an 8-band SeaWiFS scene.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Hilger, K. B. (Intern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
Pages: 717-724
Publication date: 2001

Decomposition of spectra using maximum autocorrelation factors
This paper addresses the problem of generating a low dimensional representation of the variation present in a set of spectra, e.g. reflection spectra recorded from a series of objects. The resulting low dimensional description may subsequently be input through variable selection schemes into classification or regression type analyses. A featured method for low dimensional representation of multivariate datasets is Hotellings principal components transform. We will extend the use of principal components analysis incorporating new information into the algorithm. This new information consists of the fact that given a spectrum we have a natural order of the input $\underline{variables}$. This is similar to Switzers maximum autocorrelation factors, where a natural order of $\underline{observations}$ pixels in multispectral images is utilized. However, in order to utilize an ordering of the input $\underline{variables}$ we need a non-trivial reformulation of the maximum autocorrelation problem in Q-mode. We call the resulting transformation for Q-MAF. The resulting new variables can be interpreted as a frequency composition of the spectra. But contrary to ordinary Fourier decomposition these new variables are located in frequency as well as well wavelength. The proposed algorithm is tested on 100 samples of NIR spectra of wheat.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nørgaard, N. (ed.) (Ekstern)
Publication date: 2001
Integrating prior knowledge and structure from motion
A new approach for formulating prior knowledge in structure from motion is presented, where the structure is viewed as a 3D stochastic variable, hereby priors are more naturally expressed. It is demonstrated that this formulation is efficient for regularizing structure reconstruction via prior knowledge. Specifically algorithms for imposing priors in the proposed formulation are presented.

Operation analysis of insulation materials
This paper address the problems of generating a low dimensional representation of the shape variation present in a set of shapes represented by a number of landmark points. First, we will present alternatives to the featured Least-Squares Procrustes alignment based on the L1-norm and the L-inf-norm. Second, we will define a new shape decomposition based on the Maximum Autocorrelation Factor (MAF) analysis, and investigate and compare its properties to the Principal Components Analysis (PCA). It is shown that Molgedey-Schuster algorithm for Independent Component Analysis (ICA) is equivalent to the MAF analysis. The shape MAF analysis utilises the natural order of landmark points along shape contours.

Q-MAF Shape Decomposition
This paper address the problems of generating a low dimensional representation of the shape variation present in a set of shapes represented by a number of landmark points. First, we will present alternatives to the featured Least-Squares Procrustes alignment based on the L1-norm and the L-inf-norm. Second, we will define a new shape decomposition based on the Maximum Autocorrelation Factor (MAF) analysis, and investigate and compare its properties to the Principal Components Analysis (PCA). It is shown that Molgedey-Schuster algorithm for Independent Component Analysis (ICA) is equivalent to the MAF analysis. The shape MAF analysis utilises the natural order of landmark points along shape contours.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Guilbert, N. (Ekstern), Aanæs, H. (Intern), Larsen, R. (Intern)
Pages: 477-481
Publication date: 2001

Host publication information
Title of host publication: Proceedings of the Scandinavian Image Analysis - SCIA'01
Editor: Austvoll, I.
Main Research Area: Technical/natural sciences
Conference: Proceedings of the Scandinavian Image Analysis - SCIA'01, 01/01/2001
Electronic versions:
imm206.pdf
Links:
Source: orbit
Source-ID: 57836
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

Operation analysis of insulation materials
General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Hansen, J. D. (Intern)
Publication date: 2001

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58022
Publication: Research › Report – Annual report year: 2001

Q-MAF Shape Decomposition
General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Eiriksson, H. (Ekstern), Stegmann, M. B. (Intern), Niessen et al., W. J. (ed.) (Ekstern)
Pages: 837-844
Publication date: 2001

Host publication information
Robust and resistant 2D shape alignment

We express the alignment of 2D shapes as the minimization of the norm of a linear vector function. The minimization is done in the $l_1$, $l_2$ and the $l_{\infty}$ norms using well known standard numerical methods. In particular, the $l_1$ and the $l_{\infty}$ norm alignments are formulated as linear programming problems. The linear vector function formulation along with the different norms result in alignment methods that are both resistant from influence from outliers, robust wrt. errors in the annotation and capable of handling missing datapoints. Another reason for using other norms than the $l_2$ norm is to minimize the effect of the choice of landmarks. Examples that illustrate the properties of the different norms are given on simulated as well as real datasets.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Eiriksson, H. (Ekstern)
Publication date: 2001

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm844.pdf
Links:
Source: orbit
Source-ID: 58021
Publication: Research › Report – Annual report year: 2001

Shape Modelling Using Maximum Autocorrelation Factors

This paper addresses the problems of generating a low dimensional representation of the shape variation present in a training set after alignment using Procrustes analysis and projection into shape tangent space. We will extend the use of principal components analysis in the original formulation of Active Shape Models by Timothy Cootes and Christopher Taylor by building new information into the model. This new information consists of two types of prior knowledge. First, in many situation we will be given an ordering of the shapes of the training set. This situation occurs when the shapes of the training set are in reality a time series, e.g. snapshots of a beating heart during the cardiac cycle or when the shapes are slices of a 3D structure, e.g. the spinal cord. Second, in almost all applications a natural order of the landmark points along the contour of the shape is introduced. Both these types of knowledge may be used to defined Shape Maximum Autocorrelation Factors. The resulting point distribution models are compared to ordinary principal components analysis using leave-one-out validation.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern)
Pages: 98-103
Publication date: 2001

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Editor: Austvoll, I.
Main Research Area: Technical/natural sciences
Conference: Proceedings of the Scandinavian Image Analysis Conference (SCIA'01), 01/01/2001
Electronic versions: imm208.pdf
Links:
Low-dimensional modeling and dynamics of the flow in a lid driven cavity with a rotating rod

General information
State: Published
Organisations: Fluid Mechanics, Department of Mechanical Engineering, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Dynamical systems, Department of Mathematics
Authors: Jørgensen, B. H. (Intern), Larsen, R. (Intern), Sørensen, J. N. (Intern), Brøns, M. (Intern)
Publication date: Nov 2000

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Series: ET-PHD
Number: 2000-02
Main Research Area: Technical/natural sciences
Electronic versions:
Hoffman.PDF

3D Bayesian contextual classifiers
We extend a series of multivariate Bayesian 2-D contextual classifiers to 3-D by specifying a simultaneous Gaussian distribution for the feature vectors as well as a prior distribution of the class variables of a pixel and its 6 nearest 3-D neighbours.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern)
Pages: 518-524
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Image Processing
Volume: 10
Issue number: 3
ISSN (Print): 1057-7149
Ratings:
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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 6.73 SJR 2.102 SNIP 3.318
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.1 SNIP 3.886 CiteScore 6.36
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.553 SNIP 4.347 CiteScore 5.81
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
A multivariate approach to seismic 4D analysis, Troll West Oil Province.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
Publication date: 2000

Publication information
Publisher: IMM Publications
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200905
Publication: Research - peer-review › Report – Annual report year: 2000
Sensitivity study of a semiautomatic supervised classifier applied to minerals from x-ray mapping images
This paper addresses the problem of assessing the robustness with respect to change in parameters of an integrated training and classification routine for minerals commonly encountered in siliciclastic or carbonate rocks. Twelve chemical elements are mapped from thin sections by energy dispersive spectroscopy (EDS) in a scanning electron microscope (SEM). Extensions to traditional multivariate statistical methods are applied to perform the classification. Training sets are grown from one or a few seed points by a method that ensures spatial and spectral closeness of observations. Spectral closeness is obtained by excluding observations that have high Mahalanobis distances to the training class mean. Spatial closeness is obtained by requiring connectivity. The marginal effects of changes in the parameters that are input to the seed growing algorithm are evaluated. Initially, the seed is expanded to a small area in order to allow for the estimation of a variance-covariance matrix. This expansion is controlled by upper limits for the spatial and Euclidean spectral distances from the seed point. Second, after this initial expansion the growing of the training set is controlled by an upper limit for the Mahalanobis distance to the current estimate of the class centre. Also, the estimates of class centres and covariance matrices may be continuously updated or the initial estimates may be used. Finally, the effect of the operator's choice of seed among a number of potential seeding points is evaluated. After training, a standard quadratic classifier is applied. The performance for each parameter setting is measured by the overall misclassification rate on an independently generated validation set. The classification method is presently used as a routine petrographical analysis method at Norsk Hydro Research Centre.
Supervised Mineral Classification with Semi-automatic Training and Validation Set Generation in Scanning Electron Microscope Energy Dispersive Spectroscopy Images of Thin Sections

This paper addresses the problem of classifying minerals common in siliciclastic and carbonate rocks. Twelve chemical elements are mapped from thin sections by energy dispersive spectroscopy in a scanning electron microscope (SEM). Extensions to traditional multivariate statistical methods are applied to perform the classification. First, training and validation sets are grown from one or a few seed points by a method that ensures spatial and spectral closeness of observations. Spectral closeness is obtained by excluding observations that have high Mahalanobis distances to the training class mean. Spatial closeness is obtained by requesting connectivity. Second, class consistency is controlled by forcing each class into 5–10 subclasses and checking the separability of these subclasses by means of canonical discriminant analysis. Third, class separability is checked by means of the Jeffreys–Matusita distance and the posterior probability of a class mean being classified as another class. Fourth, the actual classification is carried out based on four supervised classifiers all assuming multinormal distributions: simple quadratic, a contextual quadratic, and two hierarchical quadratic classifiers. Overall weighted misclassification rates for all quadratic classifiers are very low for both the training (0.25–0.33%) and validation sets (0.65–1.13%). Finally, the number of rejected observations in routine runs is checked to control the performance of the SEM image acquisition and the classification. Although the contextual classifier performs marginally best on the validation set, the simple quadratic classifier is chosen in routine classifications because of the lower processing time required. The method is presently used as a routine petrographical analysis method at Norsk Hydro Research Centre. The data can be approximated by a Poisson distribution. Accordingly, the square root of the data has constant variance and a linear classifier can be used. Near orthogonal input data, enable the use of a minimum distance classifier. Results from both linear and quadratic minimum distance classifications are described briefly.
Sensitivity study of a semiautomatic supervised classifier applied to minerals from x-ray mapping images

This paper addresses the problem of assessing the robustness with respect to change in parameters of an integrated training and classification routine for minerals commonly encountered in siliciclastic or carbonate rocks. Twelve chemical elements are mapped from thin sections by energy dispersive spectroscopy (EDS) in a scanning electron microscope (SEM). Extensions to traditional multivariate statistical methods are applied to perform the classification. Training sets are grown from one or a few seed points by a method that ensures spatial and spectral closeness of observations. Spectral closeness is obtained by excluding observations that have high Mahalanobis distances to the training class mean. Spatial closeness is obtained by requiring connectivity. The marginal effects of changes in the parameters that are input to the seed growing algorithm are evaluated. Initially, the seed is expanded to a small area in order to allow for the estimation of a variance-covariance matrix. This expansion is controlled by upper limits for the spatial and Euclidean spectral distances from the seed point. Second, after this initial expansion the growing of the training set is controlled by an upper limit for the Mahalanobis distance to the current estimate of the class centre. Also, the estimates of class centres and covariance matrices may be continuously updated or the initial estimates may be used. Finally, the effect of the operator's choice of seed among a number of potential seeding points is evaluated. After training, a standard quadratic classifier is applied. The performance for each parameter setting is measured by the overall misclassification rate on an independently generated validation set. The classification method is presently used as a routine petrographical analysis method at Norsk Hydro Research Centre.

**Automatic Classification of Minerals from SEM EDS Images**


**General Information**
- State: Published
- Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
- Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern), Rykkje, J. M. (Ekstern), Ramm, M. (Ekstern)
- Publication date: 1998

**Host publication Information**
- Title of host publication: Mineralogical Society Winter Meeting: Microbeam Techniques in the Geosciences. Burlington House
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 200073
- Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

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**Estimation of Dense Image Flow Fields in Fluids**

The estimation of flow fields from time sequences of satellite imagery has a number of important applications. For visualisation of cloud or sea ice movements in sequences of crude temporal sampling a satisfactory non-blurred temporal interpolation can be performed only when the flow field or an estimate there-of is known. Estimated flow fields in weather satellite imagery might also be used on an operational basis as inputs to short-term weather prediction. In this article we describe a method for the estimation of dense flow fields. Local measurements of motion are obtained by analysis of the local energy distribution, which is sampled using a set of 3-D spatio-temporal filters. The estimated local energy distribution also allows us to compute a confidence measure of the estimated local normal flow. The algorithm furthermore utilises Markovian random fields in order to integrate the local estimates of normal flows into a dense flow field using measures of spatial smoothness. To obtain smoothness we will constrain first order derivatives of the flow field. The performance of the algorithm is illustrated by the estimation of the flow fields corresponding to a sequence of Meteosat thermal images. The estimated flow fields are used in a temporal interpolation scheme.

**General Information**
- State: Published
- Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
- Authors: Larsen, R. (Intern), Conradsen, K. (Intern), Ersbøll, B. K. (Intern)
- Pages: 256-264
- Publication date: 1998
- Main Research Area: Technical/natural sciences

**Publication Information**
- Journal: Geoscience and Remote Sensing, IEEE Transactions on
- Volume: 36
- Issue number: 1
- ISSN (Print): 0196-2892
- Ratings:
  - BFI (2018): BFI-level 2
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 2
Fusion of SPOT XS and ortoPhoto Data using a Markov Random Field Model

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Conradsen, K. (Intern), Ersbøll, B. K. (Intern), Larsen, R. (Intern), Nielsen, A. A. (Intern), Nielsen, T. H. (Ekstern)
Pages: 25-30
Publication date: 1998

Semi-automatic supervised classification of minerals from x-ray mapping images
This paper addresses the problem of assessing the robustness with respect to change in parameters of an integrated training and classification routine for minerals commonly encountered in siliciclastic or carbonate rocks. Twelve chemical elements are mapped from thin sections by energy dispersive spectroscopy (EDS) in a scanning electron microscope (SEM). Extensions to traditional multivariate statistical methods are applied to perform the classification. Training sets are grown from one or a few seed points by a method that ensures spatial and spectral closeness of observations. Spectral closeness is obtained by excluding observations that have high Mahalanobis distances to the training class mean. Spatial closeness is obtained by requiring connectivity. The marginal effects of changes in the parameters that are input to the seed growing algorithm are evaluated. Initially, the seed is expanded to a small area in order to allow for the estimation of a variance-covariance matrix. This expansion is controlled by upper limits for the spatial and Euclidean spectral distances from the seed point. Second, after this initial expansion the growing of the training set is controlled by an upper limit for the Mahalanobis distance to the current estimate of the class centre. Also, the estimates of class centres and covariance matrices may be continuously updated or the initial estimates may be used. Finally, the effect of the operator's choice of seed among a number of potential seeding points is evaluated. After training, a standard quadratic classifier is applied. The performance for each parameter setting is measured by the overall misclassification rate on an independently generated validation set. The classification method is presently used as a routine petrographical analysis method at Norsk Hydro Research Centre.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Flesche, H. (Ekstern), Larsen, R. (Intern), Rykkje, J. M. (Ekstern), Ramm, M. (Ekstern)
Pages: 473-478
Publication date: 1998
3-D contextual Bayesian classifiers

In this paper we will consider extensions of a series of Bayesian 2-D contextual classification procedures proposed by Owen (1984) Hjort & Mohn (1984) and Welch & Salter (1971) and Haslett (1985) to 3 spatial dimensions. It is evident that compared to classical pixelwise classification further information can be obtained by taking into account the spatial structure of image data. The 2-D algorithms mentioned above consist of basing the classification of a pixel on the simultaneous distribution of the values of a pixel and its four nearest neighbours. This includes the specification of a Gaussian distribution for the pixel values as well as a prior distribution for the configuration of class variables within the cross that is made of a pixel and its four nearest neighbours. We will extend these algorithms to 3-D, i.e. we will specify a simultaneous Gaussian distribution for a pixel and its 6 nearest 3-D neighbours, and generalise the class variable configuration distributions within the 3-D cross given in 2-D algorithms. The new 3-D algorithms are tested on a synthetic 3-D multivariate dataset.

Automated Image Analysis in Undetermined Sections of Human Permanent Third Molars

A computerized histomorphometric analysis was made of Karnovsky-fixed, hydroxethylmethacrylate embedded and toluidine blue/pyronin-stained sections to determine: (1) the two-dimensional size of the coronal odontoblasts given by
their cytoplasm:nucleus ratio; (2) the ratio between the number of coronal odontoblasts and dentinal tubules; and (3) the relation between odontoblast size and adjacent predentine. All conditions were measured in relation to three well-defined sectioning profiles of the dentinal tubules. The sections were randomly taken from 10 unerupted and erupted third-molar crowns. Sixty-three photomicrographs (x100), equally distributed among the three sectioning profiles, were scanned in a high-resolution scanner to produce images for the analysis. After initial user interaction for the description of training classes on one image, an automatic segmentation of the images with respect to odontoblast cell nuclei, cytoplasm and background was computed by statistical discriminant analysis. In longitudinal profiles of the dentinal tubules the cytoplasm:nucleus ratio in erupted teeth was 3.1 ±0.54, and the mean of the odontoblast cell:dentinal tubule ratio was 1.19 ±0.20. Analysis of cytoplasm:nucleus ratio and the adjacent predentine in relation to the chosen sectioning profiles disclosed that there was less variation in the predentine measurements in the longitudinal sections. Thus, in future two-dimensional studies of the odontoblast-predentine region only longitudinal sectioning profiles should be analysed. The use of advanced image processing on undemineralized tooth sections provides a rational foundation for further work on the reactions of the odontoblasts to external injuries including dental caries.
Classification of Minerals from SEM EDS Images: Development of a Model for Classification of 27 Minerals Siliciclastic and Carbonate Rocks

**General information**
- State: Published
- Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
- Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
- Publication date: 1997

**Publication information**
- Original language: English
- Series: Norsk Hydro internal report
- Number: R-078852
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 200909
- Publication: Research - peer-review › Report – Annual report year: 1997

Development of a Model for Classification of 22 Minerals in Siliciclastic Rocks Based on SEM EDS Images.

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- State: Published
- Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
- Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
- Publication date: 1997

**Publication information**
- Original language: English
- Series: Norsk Hydro internal report
- Number: R-078852
- Main Research Area: Technical/natural sciences
- Source: orbit
- Source-ID: 200908
- Publication: Research - peer-review › Report – Annual report year: 1997

Estimation of Centers and Stagnation points in optical flow fields

In a topological sense fluid flows are characterised by their stagnation points. Given a temporal sequence of images of fluids we will consider the application of local polynomials to the estimation of smooth fluid flow fields. The normal flow at intensity contours is estimated from the local distribution of spatio-temporal energy, which is sampled using a set of spatio-temporal quadrature filters. These observations of normal flows are then integrated into smooth flow fields by locally approximating first order polynomials in the spatial coordinates to the flow vectors. This technique furthermore allows us to give a qualitative local description of the flow field and to estimate the position of stagnation points (e.g. nodes, saddles, and centers). We will apply the algorithm to two data sets. The first sequence consists of infrared images from the meteorological satellite Meteosat. Here the purpose is that of estimating cloud motion. The second sequence visualises the airflow in a model of a livestock building by inducing smoke in the air inlets and illuminating a plane using a laser sheet. In this case the task is to estimate the flow field in order to evaluate the ventilation system.

**General information**
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- Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
- Authors: Larsen, R. (Intern)
- Publication date: 1997

**Host publication information**
- Title of host publication: Proceedings of the 6th Danisk Conference on Pattern Recognition and Image Analysis (DANKOMB, DSAGM yearly meeting), Aug.
- Publisher: Department of Computer Science, University of Copenhagen (DIKU)
- Main Research Area: Technical/natural sciences
- Conference: Proceedings of the 6th Danisk Conference on Pattern Recognition and Image Analysis (DANKOMB, DSAGM yearly meeting), Aug., 01/01/1997
- stagnation points, optical flow
- Electronic versions: imm1117.pdf
Estimation of fluid flow fields and their stagnation points
Given a temporal sequence of images of fluids we will use local polynomials to regularise observations of normal flows into smooth flow fields. This technique furthermore allows us to give a qualitative local description of the flow field and to estimate the position of stagnation points. The algorithm is applied to two data sets. First a series of Meteosat images are processed with the purpose of estimating cloud motion. Secondly, the airflow in livestock buildings is estimated using the technique on images recorded of smoke patterns illuminated by a laser sheet. Here the purpose is the evaluation of the ventilation system.

Pre-processing and Classification of GER 3715 Data: T3F1: DANMAC Data Report.

Restoration of Hyperspectral Push-Broom Scanner Data
Several effects combine to distort the multispectral data that are obtained from push-broom scanners. We develop an algorithm for restoration of such data, illustrated on images from the ROSIS scanner. In push-broom scanners variation between elements in the detector array results in a strong striping along flight lines. A non-systematic striping is also present along flight lines. Furthermore, line drop-outs occur, and finally, various types of electronic noise of salt-and-pepper type are also present. We describe techniques for the correction for all these types of effects. Line drop-outs are located automatically using line means statistics, and if present new pixel values are interpolated from the neighbouring lines. Stripping along and across flight lines is corrected for by adjusting the line and column means, respectively. This restoration is carried out in stationary parts of the image, for instance over water. Following these initial corrections we use minimum/maximum autocorrelation factor (MAF) analysis in order to separate the spatially coherent signal components from the noise components. The MAF transformation is a linear transformation into new orthogonal variables that are ordered by decreasing autocorrelation. In this way noise channels (with low autocorrelation) can be identified and cleaned or eliminated. Also, the MAF transformation enables us to isolate electronic or aircraft engine induced noise components that have a special spatial structure. Subsequent inverse transformation back into the original spectral space results in noise corrected variables. The noise components will now have been removed from the entire original data set by working on a smaller set of noise contaminated transformed variables only. The application of the above techniques results in a dramatic increase in visual image quality.
Temporal interpolation in Meteosat images

The geostationary weather satellite Meteosat supplies us with a visual and an infrared image of the earth every 30 minutes. However, due to transmission errors, some images may be missing. European TV weather reports are often supported by such infrared image sequences. The cloud movements in such animated films are perceived as being jerky due to the low temporal sampling rate in general and missing images in particular. In order to perform a satisfactory temporal interpolation, we estimate and use the optical flow corresponding to every image in the sequence. The estimation of the optical flow is based on image sequences where the clouds are segmented from the land/water that might also be visible in the images. Because the pixel values measured correspond directly to temperature and because clouds (normally) are colder than land/water, we use an estimated land temperature map to perform a threshold between clouds and land/water. The temperature maps are estimated using observations from the image sequence itself at cloud-free pixels and ground temperature measurements from a series of meteorological observation stations in Europe. The temporal interpolation of the images is based on a path of each pixel determined by the estimated optical flow. The performance of the algorithm is illustrated by the interpolation of a sequence of Meteosat infrared images.

A System for Mineral Classification from SEM EDS Image Analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
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DANMAC Status Report 1996

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Organisations: Department of Informatics and Mathematical Modeling
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Development of a model for classification of minerals based on electron microscope X-ray images: Data and method description.

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Authors: Flesche, H. (Ekstern), Nielsen, A. A. (Intern), Larsen, R. (Intern)
Publication date: 1996

Publication information
Original language: English
Series: Norsk Hydro Internal Report
Number: R-074560
Main Research Area: Technical/natural sciences
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Estimation of Airflow in Livestock Buildings using Image Analysis
In order to evaluate a given ventilation system in a livestock building and its sensitivity to wind, presence of heat sources (e.g. livestock) etc. it is of interest to estimate flow vector fields corresponding to the airflow. By introducing particles (e.g. smoke) into the air inlets of a model of a livestock building, the airflow in a laser-illuminated plane may be visualized. Based on sequences of images recorded of this plane using a video camera, estimates of 2-D flow vectors are derived locally. The local estimates of velocity are found using a set of spatio-temporal convolution filters on the image sequence. After which the local estimates are integrated to smooth flow fields using a model that incorporates spatial smoothness. The algorithms are illustrated using a scale model of a pigs sty under isothermic conditions. It should be noted that this is an non-invasive technique (laser and camera may be placed so they do not disturb the airflow) for estimating air velocity in a 2-D plane.

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Authors: Larsen, R. (Intern)
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Title of host publication: Proceedings of the 5th International Conference on Air distribution in Rooms (ROOMVENT 96)
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ventilation, fluid flow, optical flow, markov random field
Electronic versions: imm217.pdf
Multivariate Statistical Analysis of Airborne Gamma Ray Detector Data

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Conradsen, K. (Intern)
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Publisher: Department of Mathematical Modelling, Technical University of Denmark
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Main Research Area: Technical/natural sciences
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Authors: Larsen, R. (Intern), Grunkin, M. (Intern)
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Pre-processing and Classification of EMISAR Data: PM019: DANMAC Data Report.

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Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
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Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
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Pre-processing and Classification of EMISAR Data: PM025: DANMAC Data Report

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Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
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Publication information
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Original language: English
Pre-processing and Classification of GER 3715 Data: T2F1: DANMAC Data Report.

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Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
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Publication information
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Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200957
Publication: Research - peer-review › Report – Annual report year: 1996

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
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Original language: English
Main Research Area: Technical/natural sciences
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Pre-processing and Classification of GER 3715 Data: T2F7: DANMAC Data Report.

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
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Main Research Area: Technical/natural sciences
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RoxAnn Measurements and Video based Mussel Mapping from Øresund, Denmark: Data Report.

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Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Conradsen, K. (Intern)
Publication date: 1996

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark
Estimation of Airflow in livestock Buildings.

The well-being of the animals (e.g. pigs) in livestock buildings is contingent on adequate ventilation. Depending on the construction of the ventilation system draught may be introduced into the buildings. Obviously this is an unwanted effect, that might lead to decreasing growth of and increasing sickness among the livestock. Therefore it is of interest to estimate flow vector fields corresponding to the airflow introduced by a given ventilation system. By introducing particles (e.g. smoke or soapbubbles) into the air-inlets of a model of a livestock building, the airflow in an laser-illuminated plane may be visualized. Based of sequences of images recorded of this plane local measurements of the velocity field are obtained by analysis of the local energy distribution, which is sampled using a set of 3-D spatio-temporal Gabor filters. We will show how physically inspired a priori distribution of the flow field may be used to integrate the local observations to a smooth field.

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern)
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Title of host publication: Proceedings of the 4th Danish Conference on Pattern Recognition and Image Analysis (DANKOMB, DSAGM yearly meeting), Aug. 14-15
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Main Research Area: Technical/natural sciences
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markov random fields, optical flow
Electronic versions: imm1116.pdf
Source: orbit
Source-ID: 200487
Publication: Research › Article in proceedings – Annual report year: 1995

Estimation of Dense Image Flow Fields in Fluids

The estimation of dense flow fields from time sequences of satellite imagery has a number of important applications. For visualization of cloud or sea ice movements in sequences of crude temporal sampling a satisfactory non blurred temporal interpolation can be performed only when the flow field or an estimate there-of is known. Estimated flow fields in weather satellite imagery might also be used on an operational basis as inputs to short-term weather prediction. In this article we describe a method for the estimation of dense flow fields. Local measurements of motion are obtained by analysis of the local energy distribution, which is sampled using a set of 3-D spatio-temporal filters. The estimated local energy distribution also allows us to compute a certainty measure of the estimated local flow. The algorithm furthermore utilizes Markovian random fields in order to incorporate smoothness across the field. To obtain smoothness we will constrain first as well as second order derivatives of the flow field. The performance of the algorithm is illustrated by the estimation of the flow fields corresponding to a sequence of Meteosat thermal images. The estimated flow fields are used in a temporal interpolation scheme.

General information
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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Conradsen, K. (Intern), Ersbøll, B. K. (Intern)
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Main Research Area: Technical/natural sciences
markov random fields, optical flow, local orientation
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Estimation of visual motion in image sequences

The problem of estimation of visual motion from sequences of images has been considered within a framework consisting of three stages of processing. First the extraction of motion invariants, secondly a local measurement of visual motion, and third integration of local measurements in conjunction with a priori knowledge. We have surveyed a series of attempts to extract motion invariants. Specifically we have illustrate the use of local Fourier phase. The Fourier phase is shown to define the local shape of the signal, thus accurately localizing an event. Different strategies for local measurement of motion under an assumption of translatory motion has been considered. Furthermore we have described methods for quantifying the directional certainty with which we have measured the local displacement. A method based on local estimation of the spatio temporal orientation is generalized to give a continuous description of certainty of the estimated motion. Examples on application of the techniques are given. With respect to integration of local measurements, we have surveyed different techniques within a Bayesian framework. Generalization of prior distributions using 2-D Markov random fields are given. In particular we have investigated the use of smoothness of the second order derivatives, and the use of edge model and prior distributions for the field that favor discontinuities to characterize the motion field. A successful implementation of a temporal interpolation in a sequence of weather satellite images based on the estimated motion field is shown.
restored MNFs and transforming back into the original image space gives restored original bands. If we want to remove salt-and-pepper noise also, we can replace the noise-only MNFs by their mean value before transforming back into the original image space. This noise removal is very important along with atmospheric correction of the data before performing physically oriented analysis.

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Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern)
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Restoration of GERIS Data Using the Maximum Noise Fractions Transform,

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern)
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Publisher: Technical University of Denmark (DTU)
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Temporal Interpolation in Meteorological Satellite Image Sequences

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Authors: Larsen, R. (Intern)
Publication date: 1994

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Source: orbit
Source-ID: 200488
Publication: Research › Article in proceedings – Annual report year: 1994


General information
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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Windfeld, K. (Ekstern), Ersbøll, B. K. (Intern), Larsen, R. (Intern), Hartelius, K. (Intern), Olsen, C. K. (Ekstern)
Publication date: 1993
**Estimation of Motion Vector Fields**

This paper presents an approach to the estimation of 2-D motion vector fields from time varying image sequences. We use a piecewise smooth model based on coupled vector/binary Markov random fields. We find the maximum a posteriori solution by simulated annealing. The algorithm generate sample fields by means of stochastic relaxation implemented via the Gibbs sampler.

**New Technologies for Mineral Exploration and Surveillance of Environmental Impacts of Mining Operations - Based on Remote Sensing and Multi-dataset Analysis. Extended Progress Report. CEC funded project no. BRE2-CT92-0201**

**Orthogonal Transformations of GER data**

**Orthogonal Transformations of GER data**

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**General information**

**State:** Published

**Organisations:** Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling

**Authors:** Larsen, R. (Intern)

**Pages:** 37-42

**Publication date:** 1993
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Pages: 129-144
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Title of host publication: Proceedings of the 8th Visionday, AUC, November 25th, 1992, -- Imaging and Active Vision
Publisher: Danish Image Processing Consortium, 8th Visionday
Editor: Granum, E.
Main Research Area: Technical/natural sciences
maximum noise fractions, fourier filtering
Source: orbit
Source-ID: 200490
Publication: Research › Article in proceedings – Annual report year: 1992