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

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing
Authors: Malmgren-Hansen, D. (Intern), Nielsen, A. A. (Intern), Engholm, R. (Ekstern), Skriver, H. (Intern)
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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.
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Change detection in multi-temporal dual polarization Sentinel-1 data
Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a time series of 19 multilook, dual polarization Sentinel-1 SAR data in the covariance matrix representation (with diagonal elements only) is carried out. The omnibus test statistic and its factorization detect if and when change occurs.

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Authors: Nielsen, A. A. (Intern), Canty, M. J. (Ekstern), Skriver, H. (Intern), Conradsen, K. (Intern)
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Correction to "Change Detection in Full and Dual Polarization, Single- and Multi-Frequency SAR Data"
When the covariance matrix formulation is used for multi-look polarimetric synthetic aperture radar (SAR) data, the complex Wishart distribution applies. Based on this distribution a test statistic for equality of two complex variance-covariance matrices and an associated asymptotic probability of obtaining a smaller value of the test statistic are given. In a case study airborne EMISAR C- and L-band SAR images from the spring of 1998 covering agricultural fields and wooded areas near Foulum, Denmark, are used in single- and bi-frequency, bi-temporal change detection with full and dual polarimetry data.

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Improving SAR Automatic Target Recognition Models with Transfer Learning from Simulated Data

Data-driven classification algorithms have proved to do well for automatic target recognition (ATR) in synthetic aperture radar (SAR) data. Collecting data sets suitable for these algorithms is a challenge in itself as it is difficult and expensive. Due to the lack of labeled data sets with real SAR images of sufficient size, simulated data play a big role in SAR ATR development, but the transferability of knowledge learned on simulated data to real data remains to be studied further. In this letter, we show the first study of Transfer Learning between a simulated data set and a set of real SAR images. The simulated data set is obtained by adding a simulated object radar reflectivity to a terrain model of individual point scatters, prior to focusing. Our results show that a Convolutional Neural Network (Convnet) pretrained on simulated data has a great advantage over a Convnet trained only on real data, especially when real data are sparse. The advantages of pretraining the models on simulated data show both in terms of faster convergence during the training phase and on the end accuracy when benchmarked on the Moving and Stationary Target Acquisition and Recognition data set. These results encourage SAR ATR development to continue the improvement of simulated data sets of greater size and complex scenarios in order to build robust algorithms for real life SAR ATR applications.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Microwaves and Remote Sensing, Terma A/S
Maximum auto-mutual-information factor analysis

Based on the information theoretical measure mutual information derived from entropy and Kullback-Leibler divergence, an alternative to maximum autocorrelation factor analysis is sketched.
Site Monitoring with Synthetic Aperture Radar Satellite Imagery

Based on a statistical test for the equality of polarimetric matrices following the complex Wishart distribution and a factorization of the test statistic, change analysis in a time series of multi-look polarimetric SAR data in variance-covariance or polarimetric matrix representation is carried out. The test statistic and its factorization detect if and when change(s) occur. This paper provides a short explanation of the method, describes available software, and gives examples of potential applications for site monitoring.
Visualization of and Software for Omnibus Test Based Change Detected in a Time Series of Polarimetric SAR Data

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

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ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.68 SNIP 0.91 CiteScore 1.04
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Scopus rating (2011): SJR 0.634 SNIP 0.664 CiteScore 0.95
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An omnibus likelihood test statistic and its factorization for change detection in time series of polarimetric SAR data

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

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

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

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

Determining the Points of Change in Time Series of Polarimetric SAR Data

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

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Scopus rating (2009): SJR 2.563 SNIP 3.064
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.032 SNIP 3.156
Identification of Dynamic Cover Types in Wetlands by using Multitemporal Cross-polarized Sentinel-1 Images

Monitoring of long-term land-use and land-cover change patterns may be biased by seasonal changes of different surface properties (e.g. hydrology, phenology, etc.) which become even more prominent in highly dynamic ecosystems such as wetlands (Crews-Meyer, 2008; McClearly, Crews-Meyer and Young 2008; Dronova et al. 2011). These surface dynamics produce transitional states and fine-scale mixtures of classes that may hinder classifications and long-term change detection. Dronova et al. (2015) proposed the term “Dynamic Cover Types” (DCT) to refer to such areas of regimes of periodic or seasonal change. Examples of DCT in the context of wetlands would be seasonally inundated forests, temporal water bodies and waterways, or harvests of reeds and crops such as rice. We assess the spatio-temporal extent of DCT in two study sites; The Camargue, a large coastal wetland in Southern France, and the Lagoon of Fuente de Piedra, a small wetland in Southern Spain. For that we use a multitemporal change detection procedure for polarimetric SAR imagery based on the Complex Wishart distribution developed recently by Conradsen et al (2015), (to be published) and an innovative open source software implementation which makes use of Ipython Notebooks and Docker containers (http://mortcanty.github.io/SARDocker/). The procedure carries out a series of change detection processing routines for the whole time series with a desired significance level. It uses multilook, geocoded and terrain corrected intensity images in C2 matrix. These were generated in the Sentinel Application Platform (SNAP) using 12 Sentinel-1 images (Interferometric Wide, Single Look Complex and cross-polarized) with a monthly resolution. The methodology proposed here for change detection is relatively easy to use and utilizes only open source and free data. It enables an operational monitoring service of short-term change detection. No calibration or validation needed, only interpretation of changes using local knowledge. This has important implications for operational standardized monitoring service such as the ones developed in the –Satellite-based Wetland Observation Service (SWOS) Horizon 2020 project. Besides its easiness to use, this methodology has other important advantages: First, the fine spatial and temporal resolutions of Sentinel-1 SAR data allow us to detect short-time changes for a complete water year regardless of the cloud cover. Second, change detection methods based on classification are affected by classification errors, whose probability of occurrence increases in dynamic and transitional landscapes (Powell et al. 2003). Our approach does not rely on classification and thus is free from such errors. Third, DCT are complex landscapes that often give rise to unique species assemblages (Parrot & Meyer 2012; Watson et. al 2014), and knowing their spatio-temporal extent will assist in biodiversity management. Fourth, annual stable features can be identified and used for training areas, which may facilitate the classification process and improve accuracies. And fifth, estimating the spatio-temporal extent of DCT might shed some light on the wide array of options in classification methodologies available and their different results (Object vs. Pixel based, Support Vector Machines, Random Forest Classifiers, and other algorithms).
Omnibus test for change detection in a time sequence of polarimetric SAR data
Based on an omnibus likelihood ratio test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated p-value and a factorization of this test statistic, change analysis in a (short) time series of multilook, polarimetric SAR data in the covariance matrix representation is carried out. The omnibus test statistic and its factorization detect if and when change(s) occur. The technique is demonstrated on airborne EMISAR C-band data but may be applied to ALOS, COSMO-SkyMed, RadarSat-2, Sentinel-1, TerraSAR-X, and Yoagan or other dual- and quad/full-pol data also.

Short-Term Change Detection in Wetlands Using Sentinel-1 Time Series
Automated monitoring systems that can capture wetlands' high spatial and temporal variability are essential for their management. SAR-based change detection approaches offer a great opportunity to enhance our understanding of complex and dynamic ecosystems. We test a recently-developed time series change detection approach (S1-omnibus) using Sentinel-1 imagery of two wetlands with different ecological characteristics; a seasonal isolated wetland in southern Spain and a coastal wetland in the south of France. We test the S1-omnibus method against a commonly-used pairwise comparison of consecutive images to demonstrate its advantages. Additionally, we compare it with a pairwise change detection method using a subset of consecutive Landsat images for the same period of time. The results show how S1-omnibus is capable of capturing in space and time changes produced by water surface dynamics, as well as by agricultural practices, whether they are sudden changes, as well as gradual. S1-omnibus is capable of detecting a wider array of short-term changes than when using consecutive pairs of Sentinel-1 images. When compared to the Landsat-based change detection method, both show an overall good agreement, although certain landscape changes are detected only by either the Landsat-based or the S1-omnibus method. The S1-omnibus method shows a great potential for an automated monitoring of short time changes and accurate delineation of areas of high variability and of slow and gradual changes.
Stable reconstruction of Arctic sea level for the 1950-2010 period

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

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

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

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

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

Good altimetric data is seen to crucial for sea level studies and profoundly for sea level reconstruction where we present a 60 years sea level reconstruction based on this new data set. We here present a new multi-decade altimetric dataset and a 60 year reconstruction of sea level based on this together with tide gauge information. From our reconstruction, we found that the Arctic mean sea level trend is around 1.5 mm +/- 0.3 mm/y for the period 1950 to 2010, between 68ºN and 82ºN. This value is in good agreement with the global mean trend of 1.8 +/- 0.3 mm/y over the same period as found by Church and White (2004). We also find significant higher trend in the Beaufort Gyre region showing an increase in sea level over the last decade up to 2011.
Arctic Sea Level Reconstruction

Reconstruction of historical Arctic sea level is very difficult due to the limited coverage and quality of tide gauge and altimetry data in the area. This thesis addresses many of these issues, and discusses strategies to help achieve a stable and plausible reconstruction of Arctic sea level from 1950 to today. The primary record of historical sea level, on the order of several decades to a few centuries, is tide gauges. Tide gauge records from around the world are collected in the Permanent Service for Mean Sea Level (PSMSL) database, and includes data along the Arctic coasts. A reasonable amount of data is available along the Norwegian and Russian coasts since 1950, and most published research on Arctic sea level extends cautiously from these areas. Very little tide gauge data is available elsewhere in the Arctic, and records of a length of several decades, as generally recommended for sea-level reconstruction, are completely absent outside the Norwegian and Russian sectors. Since the early 1990s, altimetric satellite missions have provided more spatially complete observations of sea level. This allows extraction of the primary variation patterns, which can be used as calibration for a reconstruction method. For oceanographic purposes, the altimetric record over the Arctic Ocean is inferior in quality to that of moderate latitudes, but nonetheless an invaluable set of observations. During this project, newly processed Arctic altimetry from the ERS-1/-2 and Envisat missions has become available, allowing analysis in greater detail, though much early progress on the project was based on ocean model data. Like other published sea level reconstructions, this project is based on the combination of tide gauge records and altimetry patterns. It is found that while it is possible to reconstruct the timestep differences and cumulate these to obtain a reconstructed sea-level record, this approach may yield widely variable results and is difficult to stabilize due to the many gaps in the data. A more robust approach, as described by Ray and Douglas (2011), takes into account the entirety of each tide gauge record and makes the reconstruction much less prone to drifting away over time. Unfortunately, many of the Russian-sector tide gauge records end around 1990, leaving a fairly sparse record after this. This project examines the effect of introducing a subset of the altimetric dataset as “virtual tide gauges” to remedy this sparsity, and appears to further stabilize the reconstruction. As Arctic sea level changes are particularly concentrated in the Beaufort Gyre area, this also introduces observations in an important area. However, this approach to some extent relies on relatively stationary conditions before the altimetric era, though previous research indicates largely stationary amounts of freshwater until the 1980s. This project initially aimed to obtain a robust reconstruction through the use of alternative decompositions, rather than the commonly used empirical orthogonal functions (EOFs), for the calibration. While one alternative decomposition, maximum auto correlation factors (MAFs), is investigated, it is found that preprocessing and handling of gaps (through appropriate method choice) in the tide gauge record is the primary concern for obtaining robust sea level reconstructions in the Arctic area. The reconstructions obtained in this project concern the period 1950 to 2010 using monthly data. The spatial coverage is all ocean areas above 68°N, limited to the north depending on the calibration dataset used (90°N for Drakkar calibrated reconstructions, 82°N for altimetry-based reconstructions).

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Building damage assessment after the earthquake in Haiti using two postevent satellite stereo imagery and DSMs

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

Canonical correlation analysis (CCA) is an established multivariate statistical method for finding similarities between linear combinations of (normally two) sets of multivariate observations. In this contribution we replace (linear) correlation as the measure of association between the linear combinations with the information theoretical measure mutual information (MI). We term this type of analysis canonical information analysis (CIA). MI allows for the actual joint distribution of the variables involved and not just second order statistics. While CCA is ideal for Gaussian data, CIA facilitates analysis of variables with different genesis and therefore different statistical distributions and different modalities. As a proof of concept we give a toy example. We also give an example with one (weather radar based) variable in the one set and eight spectral bands of optical satellite data in the other set.
correlation as a measure of association between variables is replaced by the information theoretical, entropy based measure mutual information, which is a much more general measure of association. We make canonical information analysis feasible for large sample problems, including for example multispectral images, due to the use of a fast kernel density estimator for entropy estimation. Canonical information analysis is applied successfully to (1) simple simulated data to illustrate the basic idea and evaluate performance, (2) fusion of weather radar and optical geostationary satellite data in a situation with heavy precipitation, and (3) change detection in optical airborne data. The simulation study shows that canonical information analysis is as accurate as and much faster than algorithms presented in previous work, especially for large sample sizes. URL: http://www.imm.dtu.dk/pubdb/p.php?6270
Change detection in a time series of polarimetric SAR images

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

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Change detection in bi-temporal data by canonical information analysis

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

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

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

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

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

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

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

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

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

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

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

General information

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Kernel versions of some orthogonal transformations

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

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Optimal Iterated Two-Class Separation in Hyperspectral Data

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

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Simulation of GNSS reflected signals and estimation of position accuracy in GNSS-challenged environment

The paper describes the development and testing of a simulation tool, called QualiSIM. The tool estimates GNSS-based position accuracy based on a simulation of the environment surrounding the GNSS antenna, with a special focus on cityscape environments with large amounts of signal reflections from non-line-of-sight satellites. The signal reflections are implemented using the extended geometric path length of the signal path caused by reflections from the surrounding buildings. Based on real GPS satellite positions, simulated Galileo satellite positions, models of atmospheric effect on the satellite signals, designs of representative environments e.g. urban and rural scenarios, and a method to simulate reflection of satellite signals within the environment we are able to estimate the position accuracy given several prerequisites as described in the paper. The result is a modelling of the signal path from satellite to receiver, the satellite availability, the extended pseudoranges caused by signal reflection, and an estimate of the position accuracy based on a least squares adjustment of the extended pseudoranges. The paper describes the models and algorithms used and a verification test where the results of QualiSIM are compared with results from collection of real GPS data in an environment with much signal reflection.
In this paper, we seek an appropriate selection of tide gauges for Arctic Ocean sea-level reconstruction based on a combination of empirical criteria and statistical properties (leverages). Tide gauges provide the only in situ observations of sea level prior to the altimetry era. However, tide gauges are sparse, of questionable quality, and occasionally contradictory in their sea-level estimates. Therefore, it is essential to select the gauges very carefully. In this study, we have established a reconstruction based on empirical orthogonal functions (EOFs) of sea-level variations for the period 1950-2010 for the Arctic Ocean, constrained by tide gauge records, using the basic approach of Church et al. (2004). A major challenge is the sparsity of both satellite and tide gauge data beyond what can be covered with interpolation, necessitating a time-variable selection of tide gauges and the use of an ocean circulation model to provide gridded time series of sea level. As a surrogate for satellite altimetry, we have used the Drakkar ocean model to yield the EOFs. We initially evaluate the tide gauges through empirical criteria to reject obvious outlier gauges. Subsequently, we evaluate the "influence" of each Arctic tide gauge on the EOF-based reconstruction through the use of statistical leverage and use this as an indication in selecting appropriate tide gauges, in order to procedurally identify poor-quality data while still including as much data as possible. To accommodate sparse or contradictory tide gauge data, careful preprocessing and regularization of the reconstruction model are found to make a substantial difference to the quality of the reconstruction and the ability to select appropriate tide gauges for a reliable reconstruction. This is an especially important consideration for the Arctic, given the limited amount of data available. Thus, such a tide gauge selection study can be considered a precondition for further studies of Arctic sea-level reconstruction.
Arctic sea-level reconstruction analysis using recent satellite altimetry
We present a sea-level reconstruction for the Arctic Ocean using recent satellite altimetry data. The model, forced by historical tide gauge data, is based on empirical orthogonal functions (EOFs) from a calibration period; for this purpose, newly retracted satellite altimetry from ERS-1 and -2 and Envisat has been used. Despite the limited coverage of these datasets, we have made a reconstruction up to 82 degrees north for the period 1950–2010. We place particular emphasis on determining appropriate preprocessing for the tide gauge data, and on validation of the model, including the ability to reconstruct known data. The relationship between the reconstruction and climatic variables, such as atmospheric pressure, and climate oscillations, including the Arctic Oscillation (AO), is examined.

A spatial-spectral approach for deriving high signal quality eigenvectors for remote sensing image transformations
Spectral decorrelation (transformations) methods have long been used in remote sensing. Transformation of the image data onto eigenvectors that comprise physically meaningful spectral properties (signal) can be used to reduce the dimensionality of hyperspectral images as the number of spectrally distinct signal sources composing a given hyperspectral scene is generally much less than the number of spectral bands. Determining eigenvectors dominated by signal variance as opposed to noise is a difficult task. Problems also arise in using these transformations on large images, multiple flight-line surveys, or temporal data sets as computational burden becomes significant. In this paper we present a spatial-spectral approach to deriving high signal quality eigenvectors for image transformations which possess an inherently ability to reduce the effects of noise. The approach applies a spatial and spectral subsampling to the data, which is accomplished by deriving a limited set of eigenvectors for spatially contiguous subsets. These subset eigenvectors are compiled together to form a new noise reduced data set, which is subsequently used to derive a set of global orthogonal eigenvectors. Data from two hyperspectral surveys are used to demonstrate that the approach can significantly speed up eigenvector derivation, successfully be applied to multiple flight-line surveys or multi-temporal data sets, derive a representative eigenvector set for the full image data set, and lastly, improve the separation of those eigenvectors representing signal as opposed to noise. (C) 2013 Elsevier B.V. All rights reserved.
Change detection in a time series of polarimetric SAR data
A test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution with an associated probability of finding a smaller value of the test statistic is introduced. Unlike tests based on pairwise comparisons between all temporally consecutive acquisitions the new omnibus test statistic and the probability measure successfully detects change in two short series of L- and C-band polarimetric EMISAR data.

Change detection in polarimetric SAR data over several time points
A test statistic for the equality of several variance-covariance matrices following the complex Wishart distribution is introduced. The test statistic is applied successfully to detect change in C-band EMISAR polarimetric SAR data over four time points.

Confidence and sensitivity of sea-level reconstructions

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

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

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, German Aerospace Center
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Publication date: 2014
Main Research Area: Technical/natural sciences
Influence analysis of Arctic tide gauges using leverages

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

Acceleration of the Greenland ice sheet mass loss as observed by GRACE: Confidence and sensitivity
We examine the scale and spatial distribution of the mass change acceleration in Greenland and its statistical significance, using processed gravimetric data from the GRACE mission for the period 2002-2011. Three different data products - the CNES/GRGS, DMT-1b and GGFC GRACE solutions - have been used, all revealing an accelerating mass loss in Greenland, though with significant local differences between the three datasets. Compensating for leakage effects, we
obtain acceleration values of -18.6 Gt / yr² for CNES/GRGS, -8.8 Gt / yr² for DMT-1b, and -14.8 Gt / yr² for GGFC. We find considerable mass loss acceleration in the Canadian Arctic Archipelago, some of which will leak into the values for Greenland, depending on the approach used, and for our computations the leakage has been estimated at up to -4.7 Gt / yr². The length of the time series of the GRACE data makes a huge difference in establishing an acceleration of the data. For both 10-day and monthly GRACE solutions, an observed acceleration on the order of 10 - 20 Gt / yr² is shown to require more than 5 yrs of data to establish with statistical significance. In order to provide an independent evaluation, ICESat laser altimetry data have been smoothed to match the resolution of the GRACE solutions. This gives us an estimated upper bound for the acceleration of about -29.7 Gt / yr² for the period 2003-2009, consistent with the acceleration values and corresponding confidence intervals found with GRACE data. © 2012 Elsevier B.V.
A kernel version of multivariate alteration detection

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

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Analysis of sea-level reconstruction techniques for the Arctic Ocean

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

General information
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Organisations: National Space Institute, Geodesy, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Automated invariant alignment to improve canonical variates in image fusion of satellite and weather radar data

Canonical correlation analysis (CCA) maximizes correlation between two sets of multivariate data. We applied CCA to multivariate satellite data and univariate radar data in order to produce a subspace descriptive of heavily precipitating clouds. A misalignment, inherent to the nature of the two data sets, was observed, corrupting the subspace. A method for aligning the two data sets is proposed, in order to overcome this issue and render a useful subspace projection. The observed corruption of the subspace gives rise to the hypothesis that the optimal correspondence, between a heavily precipitating cloud in the radar data and the associated cloud top registered in the satellite data, is found by a scale, rotation and translation invariant transformation together with a temporal displacement. The method starts by determining a conformal transformation of the radar data at the time of maximum precipitation for optimal correspondence with the satellite data at the same time. This optimization is repeated for an increasing temporal lag until no further improvement can be found. The method is applied to three meteorological events having caused heavy precipitation in Denmark. The three cases are analyzed with and without using the proposed method. In all cases, the use of pre-alignment shows significant improvements in the descriptive capabilities of the subspaces, thus supporting the posed hypothesis.
Building damage assessment after the earthquake in Haiti using two post-event satellite stereo imagery and DSMs

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

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Interpolation in laser scanned height data

General information
Kernel based orthogonalization for change detection in hyperspectral images

Kernel versions of principal component analysis (PCA) and minimum noise fraction (MNF) analysis are applied to change detection in hyperspectral image (HyMap) data. The kernel versions are based on so-called Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products are replaced by inner products between nonlinear mappings into higher dimensional feature space of the original data. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel PCA and MNF analyses handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. An example shows the successful application of (kernel PCA and) kernel MNF analysis to change detection in HyMap data covering a small agricultural area near Lake Waging-Taching, Bavaria, in Southern Germany.

In the change detection analysis all 126 spectral bands of the HyMap are included. Changes on the ground are most likely due to harvest having taken place between the two acquisitions and solar effects (both solar elevation and azimuth have changed). Both types of kernel analysis emphasize change and unlike kernel PCA, kernel MNF analysis seems to focus on the most conspicuous changes and also it gives a strong discrimination between change and no-change regions. Ordinary linear PCA or MNF analyses do not give this beautiful discrimination between change and no-change regions.

Some safe and sensible shortcuts for efficiently upscaled updates of existing elevation models

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Authors: Knudsen, T. (Ekstern), Nielsen, A. A. (Intern)
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Using leverages for objective analysis of PSMSL tide gauges in Arctic Ocean sea level reconstruction

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, National Space Institute, Geodesy
Authors: Svendsen, P. L. (Intern), Andersen, O. B. (Intern), Nielsen, A. A. (Intern)
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Acceleration of the GrIS mass loss as observed by GRACE
The mass loss of the Greenland Ice Sheet (GrIS) has previously been analysed in a variety of ways, including altimetry, gravimetry and mass budget calculations, establishing a continuing decrease in the ice mass, with a number of studies finding acceleration in the mass loss. Here, we examine this acceleration and its statistical significance, using different sets of processed gravimetric data from the GRACE mission. Using an OLS model that takes annual and subannual variation into account, we compare three different GRACE solutions, determining the spatial variability of the acceleration and confidence intervals for the overall acceleration, with additional qualitative evaluation from ICESat data.

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Main Research Area: Technical/natural sciences
Change detection in full and dual polarization SAR data and the complex Wishart distribution
A test statistic for equality of two complex variance-covariance matrices following the complex Wishart distribution with an associated probability of observing a smaller value of the test statistic is sketched. We demonstrate the use of the test statistic and the associated probability measure for change detection in both full and dual polarimetry synthetic aperture radar (SAR) data collected by the Danish EMISAR system.

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Exploring methods for combining altimetry with other data to extend the 20-year altimetric record onto a 50 year timescale

Ocean satellite altimetry has provided global sets of sea level data for the last two decades, allowing determination of spatial patterns in global sea level. For reconstructions going back further than this period, tide gauge data can be used as a proxy for the model. We examine different methods of combining satellite altimetry and tide gauge data using optimal weighting of tide gauge data, linear regression and EOFs, including automatic quality checks of the tide gauge time series. We attempt to test the sensibility of reconstruction using known and existing datasets and to test the important of augmenting the model using various proxies such as climate indices like the NAO and PDO. We will also investigate alternative transformations such as maximum autocorrelation factors (MAF), which better take into account the spatio-temporal structure of the variation. Whereas a traditional EOF analysis tries to explain as much variance as possible, the MAF transform considers noise to be uncorrelated with a spatially or temporally shifted version of itself, unlike the desired signal which will exhibit autocorrelation. For the application to global dataset it is necessary to consider and account for wrap-around of spatial shifts. Parameters from physical oceanography will be incorporated using ocean models (i.e., DRAKKAR; SODA) for a preliminary reference. Our focus is on a timescale going back approximately 50 years, allowing reasonable global availability of model and tide gauge data. This allows for better sensitivity analysis with respect to spatial distribution, and tide gauge
Linear and kernel methods for multivariate change detection

The iteratively reweighted multivariate alteration detection (IR-MAD) algorithm may be used both for unsupervised change detection in multi- and hyperspectral remote sensing imagery and for automatic radiometric normalization of multitemporal image sequences. Principal components analysis (PCA), as well as maximum autocorrelation factor (MAF) and minimum noise fraction (MNF) analyses of IR-MAD images, both linear and kernel-based (nonlinear), may further enhance change signals relative to no-change background. IDL (Interactive Data Language) implementations of IR-MAD, automatic radiometric normalization, and kernel PCA/MAF/MNF transformations are presented that function as transparent and fully integrated extensions of the ENVI remote sensing image analysis environment. The train/test approach to kernel PCA is evaluated against a Hebbian learning procedure. Matlab code is also available that allows fast data exploration and experimentation with smaller datasets. New, multiresolution versions of IR-MAD that accelerate convergence and that further reduce no-change background noise are introduced. Computationally expensive matrix diagonalization and kernel image projections are programmed to run on massively parallel CUDA-enabled graphics processors, when available, giving an order of magnitude enhancement in computational speed. The software is available from the authors’ Web sites.
Monitoring the change in colour of meat: A comparison of traditional and kernel-based orthogonal transformations

Currently, no objective method exists for estimating the rate of change in the colour of meat. Consequently, the purpose of this work is to develop a procedure capable of monitoring the change in colour of meat over time, environment and ingredients. This provides a useful tool to determine which storage environments and ingredients a manufacturer should add to meat to reduce the rate of change in colour. The procedure consists of taking multi-spectral images of a piece of meat as a function of time, clustering the pixels of these images into categories, including several types of meat, and extracting colour information from each category. The focus has primarily been on achieving an accurate categorisation since this is crucial to develop a useful method. The categorisation is done by applying an orthogonal transformation followed by k-means clustering. The purpose of the orthogonal transformation is to reduce the noise and amount of data while enhancing the difference between the categories. The orthogonal transformations principal components analysis, minimum noise fraction analysis and kernel-based versions of these have been applied to test which produce the most accurate categorisation.

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Publication information
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Volume: 3
**Optimal Class Separation in Hyperspectral Image Data: Iterated Canonical Discriminant Analysis**

This paper describes canonical discriminant analysis and sketches an iterative version which is then applied to obtain optimal separation between a region, here exemplified by either "water" or "wood/trees" and the rest of a HyMap image. We show that the iterative version greatly enhances the separation between the regions.

**Parameter optimization in the regularized kernel minimum noise fraction transformation**

Based on the original, linear minimum noise fraction (MNF) transformation and kernel principal component analysis, a kernel version of the MNF transformation was recently introduced. Inspired by we here give a simple method for finding optimal parameters in a regularized version of kernel MNF analysis. We consider the model signal-to-noise ratio (SNR) as a function of the kernel parameters and the regularization parameter. In 2-4 steps of increasingly refined grid searches we find the parameters that maximize the model SNR. An example based on data from the DLR 3K camera system is given.
Sea level reconstruction: Exploration of methods for combining altimetry with other data to beyond the 20-year altimetric record

Ocean satellite altimetry has provided global sets of sea level data for the last two decades, allowing determination of spatial patterns in global sea level. For reconstructions going back further than this period, tide gauge data can be used as a proxy for the model. We examine different methods of combining satellite altimetry and tide gauge data using optimal weighting of tide gauge data, linear regression and EOFs, including automatic quality checks of the tide gauge time series. We attempt to augment the model using various proxies such as climate indices like the NAO and PDO, and investigate alternative transformations such as maximum autocorrelation factors (MAF), which better take into account the spatio-temporal structure of the variation. We will attempt to take into account the uncertainties on thermosteric expansion and on ice sheet contributions. Our focus is a timescale going back approximately 50 years, allowing reasonable global availability of tide gauge data. This allows for better sensitivity analysis with respect to spatial distribution, and tide gauge data are available around the Arctic Ocean, which may be important for a later high-latitude reconstruction.

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Authors: Svendsen, P. L. (Intern), Andersen, O. B. (Intern), Nielsen, A. A. (Intern)
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Publisher: European Space Agency
Main Research Area: Technical/natural sciences
Conference: 20 years of Progress in Radar Altimetry, Venice-Lido, Italy, 24/09/2012 - 24/09/2012
Electronic versions:
Abstract Book
Source: dtu
Source-ID: u::6229
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012

Sea level reconstruction from satellite altimetry and tide gauge data
Ocean satellite altimetry has provided global sets of sea level data for the last two decades, allowing determination of spatial patterns in global sea level. For reconstructions going back further than this period, tide gauge data can be used as a proxy. We examine different methods of combining satellite altimetry and tide gauge data using optimal weighting of tide gauge data, linear regression and EOFs, including automatic quality checks of the tide gauge time series. We attempt to augment the model using various proxies such as climate indices like the NAO and PDO, and investigate alternative transformations such as maximum autocorrelation factors (MAF), which better take into account the spatio-temporal structure of the variation. Rather than trying to maximize the amount of variance explained, the MAF transform considers noise to be uncorrelated with a spatially or temporally shifted version of itself, whereas the desired signal will exhibit autocorrelation. This will be applied to a global dataset, necessitating wrap-around consideration of spatial shifts. Our focus is a timescale going back approximately 50 years, allowing reasonable global availability of tide gauge data. This allows for better sensitivity analysis with respect to spatial distribution, and tide gauge data are available around the Arctic Ocean, which may be important for a later high-latitude reconstruction.

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Organisations: National Space Institute, Geodesy
Authors: Svendsen, P. L. (Intern), Andersen, O. B. (Intern), Nielsen, A. A. (Intern)
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Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 14
ISSN (Print): 1607-7962
A method for unsupervised change detection and automatic radiometric normalization in multispectral data

Based on canonical correlation analysis the iteratively re-weighted multivariate alteration detection (MAD) method is used to successfully perform unsupervised change detection in bi-temporal Landsat ETM+ images covering an area with villages, woods, agricultural fields and open pit mines in North Rhine-Westphalia, Germany. A link to an example with ASTER data to detect change with the same method after the 2005 Kashmir earthquake is given. The method is also used to automatically normalize multitemporal, multispectral Landsat ETM+ data radiometrically. IDL/ENVI, Python and Matlab software to carry out the analyses is available from the authors’ websites.

General information
State: Published
Organisations: National Space Institute, Geodesy, Research Center Jülich GmbH
Authors: Nielsen, A. A. (Intern), Canty, M. J. (Ekstern)
Number of pages: 4
Publication date: 2011

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Publisher: International Society for Photogrammetry and Remote Sensing
Main Research Area: Technical/natural sciences
Computer software, Environmental engineering, MATLAB, Remote sensing, Signal detection, Iterative methods
Electronic versions:
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Links:
http://www.isprs.org/proceedings/2011/ISRSE-34/
Source: dtu
Source-ID: n:oai:DTIC-ART:compendex/389423290::30348
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Change detection for semi-automatic map database updating

General information
State: Published
Organisations: Geodesy, National Space Institute
Authors: Nielsen, A. A. (Intern), Pilemann Olsen, B. (Ekstern)
Number of pages: 27
Publication date: 2011

Publication information
Place of publication: Copenhagen
Publisher: The National Survey and Cadastre
ISBN (Print): 978-78-92107-35-0
Original language: English
Explicit signal to noise ratio in reproducing kernel Hilbert spaces

This paper introduces a nonlinear feature extraction method based on kernels for remote sensing data analysis. The proposed approach is based on the minimum noise fraction (MNF) transform, which maximizes the signal variance while also minimizing the estimated noise variance. We here propose an alternative kernel MNF (KMNF) in which the noise is explicitly estimated in the reproducing kernel Hilbert space. This enables KMNF dealing with non-linear relations between the noise and the signal features jointly. Results show that the proposed KMNF provides the most noise-free features when confronted with PCA, MNF, KPCA, and the previous version of KMNF. Extracted features with the explicit KMNF also improve hyperspectral image classification.

General information
State: Published
Organisations: Geodesy, National Space Institute, Universitat de Valencia
Authors: Gomez-Chova, L. (Ekstern), Nielsen, A. A. (Intern), Camps-Valls, G. (Ekstern)
Pages: 3570-3573
Publication date: 2011

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Title of host publication: IEEE International Geoscience and Remote Sensing Symposium Proceedings (IGARSS)
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ISBN (Print): 978-1-4577-1003-2
Main Research Area: Technical/natural sciences
DOIs: 10.1109/IGARSS.2011.6049993
Source: orbit
Source-ID: 286046
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Greenland inland ice melt-off: Analysis of global gravity data from the GRACE satellites

This paper gives an introductory analysis of gravity data from the GRACE (Gravity Recovery And Climate Experiment) twin satellites. The data consist of gravity data in the form of 10-day maximum values of 1° by 1° equivalent water height (EWH) in meters starting at 29 July 2002 and ending at 25 August 2010. Results focussing on Greenland show statistically significant mass loss interpreted as inland ice melt-off to the SE and NW with an acceleration in the melt-off occurring to the NW and a possible deceleration to the SE. Also, there are strong indications of a transition taking place in the mass loss in Greenland from mid-2004 to early 2006.

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State: Published
Organisations: Geodesy, National Space Institute, Technical University of Denmark
Authors: Nielsen, A. A. (Intern), Andersen, O. B. (Intern), Svendsen, P. L. (Ekstern)
Pages: 165-168
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Publisher: IEEE
ISBN (Print): 978-1-4577-1203-6
Main Research Area: Technical/natural sciences
DOIs: 10.1109/Multi-Temp.2011.6005074
Improved Nowcasting of Heavy Precipitation Using Satellite and Weather Radar Data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Geodesy, National Space Institute, Danish Meteorological Institute
Authors: Vestergaard, J. S. (Intern), Nielsen, A. A. (Intern), Larsen, R. (Intern), Bøvith, T. (Ekstern)
Publication date: 2011
Event: Poster session presented at Visionday: Industrial, Lyngby, Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
E3940d01.pdf

Infrastructure assessment for disaster management using multi-sensor and multi-temporal remote sensing imagery

In this paper, a new assessment system is presented to evaluate infrastructure objects such as roads after natural disasters in near-realtime. A particular aim is the exploitation of multi-sensorial and multi-temporal imagery together with further (GIS-)data in a comprehensive assessment framework. The combination is accomplished combining probabilities derived from the different data sets. The assessment system is applied to two different test scenarios evaluating roads after flooding yielding very promising results and evaluation values concerning completeness and correctness. The benefit of the data combination, in particular the multi-temporal component, demonstrates the suitability of the proposed method for different application scenarios.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Microwaves and Remote Sensing, Technische Universität München
Authors: Butenuth, M. (Ekstern), Frey, D. (Ekstern), Nielsen, A. A. (Intern), Skriver, H. (Intern)
Pages: 8575-8594
Publication date: 2011
Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.797 SNIP 1.023 CiteScore 2
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.838 SNIP 1.022 CiteScore 1.86
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.852 SNIP 1.191 CiteScore 1.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
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

State: Published
Organisations: Geodesy, National Space Institute, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Vestergaard, J. S. (Intern)
Pages: 81800S
Publication date: 2011
Conference: Image and Signal Processing for Remote Sensing XVII, USA, Prague, 01/01/2011
Main Research Area: Technical/natural sciences
Automatic change detection in RapidEye data using the combined MAD and kernel MAF methods

The IR-MAD components show changes for a large part of the entire subset. Especially phenological changes in the agricultural fields surrounding the open pit are predominant. As opposed to this, kMAF components focus more on changes in the open-cast mine (and changes due to the two clouds and their shadows, not visible in the zoom). Ground data were available from bucket-wheel excavators on the extraction side (to the northwest in the open pit) in terms of elevation data for both dates. No ground data were available for changes due to backfill (southeastern part of the open pit) or changes due to mining machines other than the bucket-wheels.

General information
State: Published
Change detection by the IR-MAD and kernel MAF methods in Landsat TM data covering a Swedish forest region

Change over time between two 512 by 512 (25 m by 25 m pixels) multispectral Landsat Thematic Mapper images dated 6 June 1986 and 27 June 1988 respectively covering a forested region in northern Sweden, is here detected by means of the iteratively reweighted multivariate alteration detection (IR-MAD) method followed by post-processing by means of kernel maximum autocorrelation factor (kMAF) analysis. The IR-MAD method builds on an iterated version of an established method in multivariate statistics, namely canonical correlation analysis (CCA). It finds orthogonal (i.e., uncorrelated) linear combinations of the multivariate data at two time points that have maximal correlation. These linear combinations are called the canonical variates (CV) and the corresponding correlations are called the canonical correlations. There is one set of CVs for each time point. The difference between the two set of CVs represent the change between the two time points and are called the MAD variates or the MADs for short. The MAD variates are invariant to linear and affine transformations of the original data. The sum of the squared MAD variates (properly normed to unit variance) gives us change variables that will ideally follow a so-called $c^2$ (chi-squared) distribution with $p$ degrees of freedom for the no-change pixels; $p$ is the number of spectral bands in the image data. Here $p=6$, the thermal band is excluded from the analyses. The $c^2$ image is the basis for calculating an image of probability for no-change, i.e., the probability for finding a higher value of the $c^2$ statistic than the one actually found. This image is the weight image in the iteration scheme mentioned above. Iterations stop when the canonical correlations stop changing. Principal component analysis (PCA) finds orthogonal (i.e., uncorrelated) linear combinations of the multivariate data that have maximal variance. A kernel version of PCA is based on a dual formulation also termed Q-mode analysis in which the data enter into the analysis via inner products in the so-called Gram matrix only. In the kernel version the inner products are replaced by inner products between nonlinear mappings into higher dimensional feature space of the original data. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This kernel version may be thought of as a nonlinear version of PCA. Maximum autocorrelation factor (MAF) analysis finds orthogonal (i.e., uncorrelated) linear combinations of the multivariate data that have maximal autocorrelation. This type of analysis can be kernelized in a fashion similar to kernel PCA. In both simple difference images, IR-MAD images and kernel MAF images grayish colours indicate no change, saturated colours indicate change. The kMAF transformation focuses on extreme
Kernel based eigenvalue-decomposition methods for analysing ham

Every consumer wants fresh ham and the way we decide whether the meat is fresh or not is by looking at the color. The producers of ham wants a long shelf life, meaning they want the ham to look fresh for a long time. The Danish company Danisco is therefore trying to develop optimal storing conditions and finding useful additives to hinder the color to change rapidly. To be able to prove which methods of storing and additives work, Danisco wants to monitor the development of the color of meat in a slice of ham as a function of time, environment and ingredients. We have chosen to use multi spectral images to monitor the change in color. We therefore have to be able to segment the ham into the different categories of which the ham consists. These categories include fat, gristle and two different types of meat. This segmentation is difficult when using the traditional orthogonal transformation methods, such as PCA, MAF or MNF. We therefore investigated the applicability of kernel based versions of these transformation. This meant implementing the kernel based methods and developing new theory, since kernel based MAF and MNF is not described in the literature yet. The traditional methods only have two factors that are useful for segmentation and none of them can be used to segment the two types of meat. The kernel based methods have a lot of useful factors and they are able to capture the subtle differences in the images. This is illustrated in Figure 1. You can see a comparison of the most useful factor of PCA and kernel based PCA respectively in Figure 2. The factor of the kernel based PCA turned out to be able to segment the two types of meat and in general that factor is much more distinct, compared to the traditional factor. After the orthogonal transformation a simple thresholding is enough to segment the ham and to detect the color of a type of meat can be done by averaging the pixels that is categorised as that type of meat. Graphs of the change of color in ham as well as more images of the segmentation is included in the article found on www.student.dtu.dk/~s062211/.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Lund University
Authors: Nielsen, A. A. (Intern), Olsson, H. (Ekstern)
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Editors: Miranda, D., Suárez, J., Crecente, R.
Main Research Area: Technical/natural sciences
Conference: Conference on Spatial Application Tools in Forestry, Lugo, Spain, 01/01/2010
Links:
Source: orbit
Source-ID: 267327
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2010
Kernel maximum autocorrelation factor and minimum noise fraction transformations

This paper introduces kernel versions of maximum autocorrelation factor (MAF) analysis and minimum noise fraction (MNF) analysis. The kernel versions are based on a dual formulation also termed Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products of the original data are replaced by inner products between nonlinear mappings into higher dimensional feature space. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel principal component analysis (PCA), kernel MAF and kernel MNF analyses handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. Three examples show the very successful application of kernel MAF/MNF analysis to 1) change detection in DLR 3K camera data recorded 0.7 seconds apart over a busy motorway, 2) change detection in hyperspectral HyMap scanner data covering a small agricultural area, and 3) maize kernel inspection. In the cases shown, the kernel MAF/MNF transformation performs better than its linear counterpart as well as linear and kernel PCA. The leading kernel MAF/MNF variates seem to possess the ability to adapt to even abruptly varying multi- and hypervariate backgrounds and focus on extreme observations.

General information

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Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Nielsen, A. A. (Intern)
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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
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Scopus rating (2013): SJR 1.67 SNIP 4.537 CiteScore 6.14
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.698 SNIP 4.694 CiteScore 5.58
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.735 SNIP 3.983 CiteScore 5.04
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.939 SNIP 4.18
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Kernel methods in orthogonalization of near-infrared hyperspectral images of maize kernels

General information
State: Published
Organisations: National Space Institute, Geodesy
Authors: Nielsen, A. A. (Intern)
Publication date: 2010
Event: Poster session presented at 8th French-Danish Workshop in Spatial Statistics and Image Analysis in Biology, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
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Source: orbit
Source-ID: 262264
Publication: Research - peer-review › Poster – Annual report year: 2010

Kernel parameter dependence in spatial factor analysis
Principal component analysis (PCA) [1] is often used for general feature generation and linear orthogonalization or compression by dimensionality reduction of correlated multivariate data, see Jolliffe [2] for a comprehensive description of PCA and related techniques. Schölkopf et al. [3] introduce kernel PCA. Shawe-Taylor and Cristianini [4] is an excellent reference for kernel methods in general. Bishop [5] and Press et al. [6] describe kernel methods among many other subjects. The kernel version of PCA handles nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. In this paper we shall apply a kernel version of maximum autocorrelation factor (MAF) [7, 8] analysis to irregularly sampled stream sediment geochemistry data from South Greenland and illustrate the dependence of the kernel width. The 2,097 samples each covering on average 5 km2 are analyzed chemically for the content of 41 elements.

General information
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Organisations: National Space Institute, Geodesy
Authors: Nielsen, A. A. (Intern)
Pages: 4240-4243
Publication date: 2010
Linear and kernel methods for multi- and hypervariate change detection

The iteratively re-weighted multivariate alteration detection (IR-MAD) algorithm may be used both for unsupervised change detection in multi- and hyperspectral remote sensing imagery as well as for automatic radiometric normalization of multi- or hypervariate multitemporal image sequences. Principal component analysis (PCA) as well as maximum autocorrelation factor (MAF) and minimum noise fraction (MNF) analyses of IR-MAD images, both linear and kernel-based (which are nonlinear), may further enhance change signals relative to no-change background. The kernel versions are based on a dual formulation, also termed Q-mode analysis, in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products of the original data are replaced by inner products between nonlinear mappings into higher dimensional feature space. Via kernel substitution, also known as the kernel trick, these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of the kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel principal component analysis (PCA), kernel MAF and kernel MNF analyses handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. In image analysis the Gram matrix is often prohibitively large (its size is the number of pixels in the image squared). In this case we may sub-sample the image and carry out the kernel eigenvalue analysis on a set of training data samples only. To obtain a transformed version of the entire image we then project all pixels, which we call the test data, mapped nonlinearly onto the primal eigenvectors. IDL (Interactive Data Language) implementations of IR-MAD, automatic radiometric normalization and kernel PCA/MAF/MNF transformations have been written which function as transparent and fully integrated extensions of the ENVI remote sensing image analysis environment. Also, Matlab code exists which allows for fast data exploration and experimentation with smaller datasets. Computationally demanding kernelization of test data with training data and kernel image projections have been programmed to run on massively parallel CUDA-enabled graphics processors, when available, giving a tenfold speed enhancement. The software will be available from the authors’ websites in the near future. A data example shows the application to bi-temporal RapidEye data covering the Garzweiler open pit mine in the Ruhr area in Germany.
Nye metoder til geobranchen

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)
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Publication date: 2010
Main Research Area: Technical/natural sciences

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10.1117/12.870781
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Seventeen years of global SSH anomalies analyzed by a maximum information based extension to EOF analysis

A kernel version of spatial factor analysis

Efficient Incorporation of Markov Random Fields in Change Detection
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

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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:

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DOIs:

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**Kernel based orthogonalization for change detection in hyperspectral image data**

**General information**

State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Nielsen, A. A. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences

Links:

http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5730

Source: orbit
Source-ID: 256778
Publication: Research - peer-review › Conference abstract for conference – 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), Aamgren, 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
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 illumination. 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

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Series: Lecture Notes in Computer Science
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Kernel empirical orthogonal function analysis of 1992-2008 global sea surface height anomaly data

General information
State: Published
Organisations: Geodesy, National Space Institute
Authors: Nielsen, A. A. (Intern), Andersen, O. B. (Intern), Knudsen, P. (Intern)
Publication date: 2009

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Main Research Area: Technical/natural sciences
Conference: MultiTemp, Mystic, Connecticut, USA, 01/01/2009

Kernel methods in orthogonalization of hyperspectral data

General information
State: Published
Organisations: National Space Institute, Geodesy
Authors: Nielsen, A. A. (Intern)
Kernel methods in orthogonalization of multi- and hypervariate data

A kernel version of maximum autocorrelation factor (MAF) analysis is described very briefly and applied to change detection in remotely sensed hyperspectral image (HyMap) data. The kernel version is based on a dual formulation also termed Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products are replaced by inner products between nonlinear mappings into higher dimensional feature space of the original data. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. This means that we need not know the nonlinear mappings explicitly. Kernel PCA and MAF analysis handle nonlinearities by implicitly transforming data into high (even infinite) dimensional feature space via the kernel function and then performing a linear analysis in that space. An example shows the successful application of kernel MAF analysis to change detection in HyMap data covering a small agricultural area near Lake Waging-Taching, Bavaria, Germany.

Kernel principal component and maximum autocorrelation factor analyses for change detection

Principal component analysis (PCA) has often been used to detect change over time in remotely sensed images. A commonly used technique consists of finding the projections along the eigenvectors for data consisting of pair-wise (perhaps generalized) differences between corresponding spectral bands covering the same geographical region acquired at two different time points. In this paper kernel versions of the principal component and maximum autocorrelation factor (MAF) transformations are used to carry out the analysis. An example is based on bi-temporal Landsat-5 TM imagery over irrigation fields in Nevada acquired on successive passes of the Landsat-5 satellite in August-September 1991. The six-band images (the thermal band is omitted) with 1,000 by 1,000 28.5 m pixels were first processed with the iteratively re-weighted MAD (IR-MAD) algorithm in order to discriminate change. Then the MAD image was post-processed with both ordinary and kernel versions of PCA and MAF analysis. Kernel MAF suppresses the noisy no-change background much more successfully than ordinary MAF. The ratio between variances of the ordinary MAF and the kernel MAF calculated in a no-change region of the images is 140 corresponding to 21.5 dB. Kernel MAF analysis also outperforms both linear and kernel PCA here (not shown).
Recent sea level change analysed with kernel EOF

This paper describes the application of a kernel version of empirical orthogonal functions (EOF) to detect patterns of interest in global monthly mean sea surface height anomalies from satellite altimetry during the last 17 years. The kernel version is based on a dual formulation also termed Q-mode analysis in which the data enter into the analysis via inner products in the Gram matrix only. In the kernel version the inner products are replaced by inner products between nonlinear mappings into higher dimensional feature space of the original data. Via kernel substitution also known as the kernel trick these inner products between the mappings are in turn replaced by a kernel function and all quantities needed in the analysis are expressed in terms of this kernel function. Results from the last 17 years have been obtained from analysing joint TOPEX and JASON-1 data over the period 1992-2008. Preliminary analysis shows some interesting features related to climate change and particularly the pulsing of the El Niño/Southern Oscillation. Large scale ocean events associated with the El Niño/Southern Oscillation related signals are conveniently concentrated in the first SSH kernel EOF modes.

Treaty Monitoring

This volume provides the reader with an overview of the state-of-the-art Earth Observation (EO) related research that deals with national and international security. An interdisciplinary approach was adopted in this book in order to provide the reader with a broad understanding on the uses of remote sensing technologies. The book therefore comprises management aspects (issues and priorities of security research, crisis response), applied methodologies and process chains (treaty monitoring, estimation of population densities and characteristics, border permeability models, damage assessment) and the latest developments in generic tools (feature recognition, change detection and visualization). Moreover, issues of data sharing and standards, as well as new approaches to training security relevant techniques, are addressed. The contributing authors are leading researchers and experts from private companies, national research institutions and international organizations, all of whom were brought together under the aegis of the European research project GMOSS (Global Monitoring for Security and Stability). This book is tailored for the scientific community that deals with the application of EO data, as well as project managers and decision makers working in the field of security having an interest in technical solutions. The integrative use of many figures and sample images are ideal in enabling the non-technical reader to grasp quickly the modern technologies that are being researched in the area of civil security. Written for: Scientists, researchers in spatial sciences as well as practitioners, politicians, decision makers at NGO's in the field of security, crisis management, risk assessment and vulnerability.
Detection of Weather Radar Clutter

Weather radars provide valuable information on precipitation in the atmosphere but due to the way radars work, not only precipitation is observed by the weather radar. Weather radar clutter, echoes from non-precipitating targets, occur frequently in the data, resulting in lowered data quality. Especially in the application of weather radar data in quantitative precipitation estimation and forecasting a high data quality is important. Clutter detection is one of the key components in achieving this goal. This thesis presents three methods for detection of clutter. The methods use supervised classification and use a range of different techniques and input data. The first method uses external information from multispectral satellite images to detect clutter. The information in the visual, near-infrared, and infrared parts of the spectrum can be used to distinguish between cloud and cloud-free areas and precipitating and non-precipitating clouds. Another method uses the difference in the motion field of clutter and precipitation measured between two radar images. Furthermore, the direction of the wind field extracted from a weather model is used. The third method uses information about the refractive index of the atmosphere as extracted from a numerical weather prediction model to predict the propagation path of the radar’s electromagnetic energy. This facilitates the prediction of areas of clutter caused by anomalous propagation of the radar’s rays. The methods are evaluated using a large independent test set, and to illustrate the performance on individual radar images three typical case examples are also evaluated. The results of the evaluation of the methods show that each method has good skill in detection of clutter with an average classification accuracy of 95%. The methods thus have the potential for increasing the quality of weather radar data in their operational use.

Automatic Radiometric Normalization of Multitemporal Satellite Imagery with the Iteratively Re-weighted MAD Transformation

A recently proposed method for automatic radiometric normalization of multi- and hyper-spectral imagery based on the invariance property of the Multivariate Alteration Detection (MAD) transformation and orthogonal linear regression is extended by using an iterative re-weighting scheme involving no-change probabilities. The procedure is first investigated with partly artificial data and then applied to multitemporal, multispectral satellite imagery. Substantial improvement over the previous method is obtained for scenes which exhibit a high proportion of change.
Change detection using polarimetric synthetic aperture radar (SAR)

General information
State: Published
Organisations: National Space Institute, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Skriver, H. (Intern), Conradsen, K. (Intern)
Publication date: 2008

Host publication information
Title of host publication: Remote Sensing for International Stability and Security : Integrating GMOSS Achievements in GMES
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 233461
Publication: Research › Article in proceedings – Annual report year: 2008

Geostatistics and Analysis of Spatial Data

General information
State: Published
Organisations: National Space Institute
Authors: Nielsen, A. A. (Intern)
Publication date: 2008

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 233464
Publication: Education › Compendium/lecture notes – Annual report year: 2008

Investigation of alternative iteration schemes for the IR-MAD algorithm

General information
State: Published
Organisations: National Space Institute
Authors: Nielsen, A. A. (Intern), Skriver, H. (Intern)
Publication date: 2008
Conference: SPIE Europe Remote Sensing Conference, Florence, Italy, 01/01/2008
Main Research Area: Technical/natural sciences

Publication information
Journal: SPIE Europe Remote Sensing Conference
Original language: English
Source: orbit
Kernel principal component analysis for change detection

Principal component analysis (PCA) is often used to detect change over time in remotely sensed images. A commonly used technique consists of finding the projections along the two eigenvectors for data consisting of two variables which represent the same spectral band covering the same geographical region acquired at two different time points. If change over time does not dominate the scene, the projection of the original two bands onto the second eigenvector will show change over time. In this paper a kernel version of PCA is used to carry out the analysis. Unlike ordinary PCA, kernel PCA with a Gaussian kernel successfully finds the change observations in a case where nonlinearities are introduced artificially.

General information
State: Published
Organisations: National Space Institute
Authors: Nielsen, A. A. (Intern), Morton, J. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: SPIE Europe Remote Sensing Conference
Publisher: SPIE - International Society for Optical Engineering
Main Research Area: Technical/natural sciences
Conference: SPIE Europe Remote Sensing Conference, 01/01/2008
Source: orbit
Source-ID: 233432
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

MAD change detection: a simple spatial extension and a nonlinear version

General information
State: Published
Organisations: National Space Institute
Authors: Nielsen, A. A. (Intern), Canty, M. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: Remote Sensing for International Stability and Security : Integrating GMOSS Achievements in GMES
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 233458
Publication: Research › Article in proceedings – Annual report year: 2008

Model-based satellite image fusion

A method is proposed for pixel-level satellite image fusion derived directly from a model of the imaging sensor. By design, the proposed method is spectrally consistent. It is argued that the proposed method needs regularization, as is the case for any method for this problem. A framework for pixel neighborhood regularization is presented. This framework enables the formulation of the regularization in a way that corresponds well with our prior assumptions of the image data. The proposed method is validated and compared with other approaches on several data sets. Lastly, the intensity-hue-saturation method is revisited in order to gain additional insight of what implications the spectral consistency has for an image fusion method.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Geodesy, National Space Institute
Authors: Aanæs, H. (Intern), Sveinsson, J. R. (Ekstern), Nielsen, A. A. (Intern), Bøvith, T. (Intern), Benediktsson, J. A. (Ekstern)
Pages: 1336-1346
Publication date: 2008
Main Research Area: Technical/natural sciences
 Advances in statistical change detection methods within the GMOSS Network

General information
State: Published
Organisations: Geodesy, National Space Institute
Authors: Canty, M. J. (Ekstern), Nielsen, A. A. (Intern)
Number of pages: 365
Publication date: 2007

Host publication information
Title of host publication: Global Monitoring for Security and Stability (GMOSS).
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 209876
Publication: Research - peer-review › Book chapter – Annual report year: 2007

Automatic normalization of multi-temporal, hyperspectral data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Canty, M. J. (Ekstern)
Publication date: 2007
Event: Abstract from 5th EARSeL Workshop on Imaging Spectroscopy : April, Bruges, Belgium,
Main Research Area: Technical/natural sciences
Electronic versions: imm5116.pdf
Source: orbit
Source-ID: 200546
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2007

Complex Wishart distribution based analysis of polarimetric synthetic aperture radar data

Multi-look, polarimetric synthetic aperture radar (SAR) data are often worked with in the so-called covariance matrix representation. For each pixel this representation gives a 3x3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are given and applied to change detection, edge detection and segmentation in polarimetric SAR data. In a case study EMISAR L-band data from 17 April 1998 and 20 May 1998 covering agricultural fields near Foulum, Denmark, are used. Soon the Japanese ALOS, the German TerraSAR-X and the Canadian RADARSAT-2 will acquire space-borne, polarimetric data making analysis based on these methods important.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Electromagnetic Systems, Department of Electrical Engineering
Authors: Nielsen, A. A. (Intern), Skriver, H. (Intern), Conradsen, K. (Intern)
General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Aanæs, H. (Intern), Sveinsson, J. R. (Ekstern), Bøvith, T. (Intern), Benediktsson, J. A. (Ekstern), Nielsen, A. A. (Intern), Gudmundsson, S. A. (Intern)
Publication date: 2007

Host publication information
Title of host publication: IGARSS 2007
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 203165
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Orthogonal transformations for change detection, Matlab code (ENVI-like headers)
Matlab code to do (iteratively reweighted) multivariate alteration detection (MAD) analysis, maximum autocorrelation factor (MAF) analysis, canonical correlation analysis (CCA) and principal component analysis (PCA) on image data; accommodates ENVI (like) header files.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Publication date: 2007

Publication information
Original language: English
Place of publication: Kgs. Lyngby
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Main Research Area: Technical/natural sciences
Electronic versions:
imm3621.zip
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3621
Source: orbit
Source-ID: 201171
Publication: Research - peer-review › Computer programme – Annual report year: 2007

The Regularized Iteratively Reweighted MAD Method for Change Detection in Multi- and Hyperspectral Data
This paper describes new extensions to the previously published multivariate alteration detection (MAD) method for change detection in bi-temporal, multi- and hypervariate data such as remote sensing imagery. Much like boosting methods often applied in data mining work, the iteratively reweighted (IR) MAD method in a series of iterations places increasing focus on “difficult” observations, here observations whose change status over time is uncertain. The MAD method is based on the established technique of canonical correlation analysis: for the multivariate data acquired at two points in time and covering the same geographical region, we calculate the canonical variates and subtract them from each other. These orthogonal differences contain maximum information on joint change in all variables (spectral bands).
The change detected in this fashion is invariant to separate linear (affine) transformations in the originally measured variables at the two points in time such as 1) changes in gain and offset in the measuring device used to acquire the data; 2) data normalization or calibration schemes that are linear (affine) in the gray values of the original variables; or 3) orthogonal or other affine transformations such as principal component (PC) or maximum autocorrelation factor (MAF) transformations. The IR-MAD method first calculates ordinary canonical and original MAD variates. In the following iterations we apply different weights to the observations, large weights are assigned to observations that show little change, i.e., for which the sum of squared, standardized MAD variates is small, and small weights are assigned to observations for which the sum is large. Like the original MAD method, the iterative extension is invariant to linear (affine) transformations of the original variables. To stabilize solutions to the (IR-)MAD problem some form of regularization may be needed. This is especially useful for work on hyperspectral data. The paper describes ordinary two-set canonical correlation analysis, the MAD transformation, the iterative extension and three regularization schemes. A simple case with real Landsat Thematic Mapper (TM) data at one point in time and (partly) constructed data at the other point in time that demonstrates the superiority of the iterative scheme over the original MAD method is shown. Also, examples with SPOT High Resolution Visible (HRV) data from an agricultural region in Kenya, and hyperspectral airborne HyMap data from a small rural area in southeastern Germany are given. The latter case demonstrates the need for regularization.
Using differential SAR interferometry for the measurement of surface displacement caused by underground nuclear explosions and comparison with optical change detection results

General information
State: Published
Organisations: Geodesy, National Space Institute
Authors: Cong, X. (Ekstern), Schlittenhart, J. (Ekstern), Gutjahr, K. (Ekstern), Soergel, U. (Ekstern), Canty, M. J. (Ekstern), Nielsen, A. A. (Intern)
Publication date: 2007

Host publication information
Title of host publication: Global Monitoring for Security and Stability (GMOSS)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 209877
Publication: Research - peer-review › Book chapter – Annual report year: 2007

Detecting Weather Radar Clutter by Information Fusion With Satellite Images and Numerical Weather Prediction Model Output
A method for detecting clutter in weather radar images by information fusion is presented. Radar data, satellite images, and output from a numerical weather prediction model are combined and the radar echoes are classified using supervised classification. The presented method uses indirect information on precipitation in the atmosphere from Meteosat-8 multispectral images and near-surface temperature estimates from the DMI-HIRLAM-S05 numerical weather prediction model. Alternatively, an operational nowcasting product called 'Precipitating Clouds' based on Meteosat-8 input is used. A scale-space ensemble method is used for classification and the clutter detection method is illustrated on a case of severe sea clutter contaminated radar data. Detection accuracies above 90 % are achieved and using an ensemble classification method the error rate is reduced by 40 %.
Detecting weather radar clutter using satellite-based nowcasting products

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Jensen, T. B. (Intern), Gill, R. S. (Ekstern), Overgaard, S. (Ekstern), Hansen, L. K. (Intern), Nielsen, A. A. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Fourth European Conference on Radar in Meteorology and Hydrology (ERAD) 2006
Main Research Area: Technical/natural sciences
Electronic versions: imm4661.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4661

Effect of catch location, season and quality on value of Icelandic cod (Gadus morhua) products

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Margeirsson, S. (Ekstern), Nielsen, A. A. (Intern), Jonsson, G. R. (Ekstern), Arason, S. (Ekstern)
Pages: 265-274
Publication date: 2006

Host publication information
Title of host publication: Seafood research from fish to dish - Quality, safety & processing of wild and farmed fish
Main Research Area: Technical/natural sciences
Electronic versions: imm4761.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4761
Long-term and high resolution measurements of bed level changes in a temperate, microtidal coastal lagoon

This study presents the results of a long-term monitoring program of bed level changes measured during 8 yr at an intertidal mudflat in a microtidal, temperate coastal lagoon. Additionally, bed level measurements obtained at a 10-min temporal resolution at the same tidal flat and at the bed of a nearby tidal channel are presented. Short-term changes in bed level are one or two orders of magnitude larger than the annual net-deposition rate, which shows that the environment is highly dynamic with respect to erosion, transport and deposition of fine-grained sediment. Some seasonality in the bed level changes was observed and there is a tendency for mudflat deposition in spring, summer and early autumn and erosion during the rest of the year, but interannual variations are large and different parts of the mudflat show different seasonal signals. A close coupling between sub- and intertidal deposition and erosion was observed. The time-series showed that some of the material eroded from the mudflat was not exported to the open sea, but instead temporarily deposited in a nearby shallow tidal channel and later returned to the mudflat during calmer weather conditions. These findings support previously published hypothesis and results of modelling studies. Based on the observed abundance of fine-grained sediment at the study sites and the high accretion rates generally found on fine-grained tidal flats in the Danish Wadden Sea area, it is argued that these fine-grained tidal flats are not seriously threatened by the expected sea level rise in the 21st century.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Andersen, T. J. (Ekstern), Pejrup, M. (Ekstern), Nielsen, A. A. (Intern)
Pages: 115-125
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Geology
Volume: 225
Issue number: 1-2
ISSN (Print): 0025-3227
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 1.537 SNIP 1.596 CiteScore 3.26
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.502 SNIP 1.354 CiteScore 2.77
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.425 SNIP 1.312 CiteScore 2.8
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.412 SNIP 1.39 CiteScore 2.54
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.714 SNIP 1.371 CiteScore 2.77
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.675 SNIP 1.276 CiteScore 2.66
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.811 SNIP 1.433
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.497 SNIP 1.429
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.304 SNIP 1.206
Segment-based change detection for polarimetric SAR data

General information
State: Published
Organisations: Department of Electrical Engineering, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Skriver, H. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: IEEE International Geoscience and Remote Sensing Symposium (IGARSS)
Main Research Area: Technical/natural sciences

Spectrally consistent satellite image fusion

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Aanæs, H. (Intern), Sveinsson, J. R. (Ekstern), Nielsen, A. A. (Intern), Benediktsson, J. A. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: 7th Nordic Signal Processing Symposium, NORSIG
Main Research Area: Technical/natural sciences

Spectrally Consistent Satellite Image Fusion with Improved Image Priors

Here an improvement to our previous framework for satellite image fusion is presented. A framework purely based on the sensor physics and on prior assumptions on the fused image. The contributions of this paper are two fold. Firstly, a method for ensuring 100% spectrally consistency is proposed, even when more sophisticated image priors are applied. Secondly, a better image prior is introduced, via data-dependent image smoothing.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Aanaes, H. (Intern), Jensen, T. B. (Intern), Sveinsson, J. (Ekstern), Benediktsson, J. (Ekstern)
Pages: 14-17
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the 7th Nordic Signal Processing Symposium : NORSIG 2006
Publisher: IEEE
ISBN (Print): 1-4244-0412-6
Main Research Area: Technical/natural sciences
Electronic versions:
Aanaes.pdf
DOIs:
10.1109/NORSIG.2006.275264

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Source: orbit
Source-ID: 195127
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Visualization and unsupervised classification of changes in multispectral satellite imagery

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Canty, M. J. (Ekstern), Nielsen, A. A. (Intern)
Pages: 3961-3975
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Volume: 27
Issue number: 18
ISSN (Print): 0143-1161
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 0.797 SNIP 1.023 CiteScore 2
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.838 SNIP 1.022 CiteScore 1.86
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.852 SNIP 1.191 CiteScore 1.79
The use of Polarimetric EMISAR for the Mapping and Characterization of the Semi-Natural Environment

Methods for segmentation and restoration of SAR data using Markov Random Fields (MRF) have been studied extensively by many researchers over the last two decades. What is of special interest is not only methods for segmentation and classification of SAR data for land cover labeling applications, but also methods for detail preservation, which have experienced a rapid growth over the past few years. The main part of this thesis concerns the development of image restoration methods that facilitate the extraction of biotope relevant information from polarimetric SAR data. Because the semi-natural environments under study are very small, it is crucial for this investigation that the restoration methods are capable of restoring fine structures as well as preserving homogeneous areas. The restorations are carried out in a signal adaptive mode using MRF in a Bayesian framework. Different a priori models are implemented in both the local optimizer Iterated Conditional Modes (ICM) and the global optimization technique Simulated Annealing (SA). A new technique for algorithm optimization is presented, which relies on ratios of SAR data and their histograms. A quantitative evaluation of the restorations based on statistics derived from the ratio images is presented together with comparative analyses of restorations using ICM and SA. The relation between the restored polarimetric SAR data and in situ data collected at two semi-natural wetland and grassland areas is investigated using multivariate techniques. The restored polarimetric SAR data are classified by using a supervised and an unsupervised classifier and comparative analyses of their performances are carried out.
An iterative extension to the MAD transformation for change detection in multi- and hyperspectral remote sensing data

We introduce an interactive segmentation method for a sea floor survey. The method is based on a deformable template classifier and is developed to segment data from an echo sounder post-processor called RoxAnn. RoxAnn collects two different measures for each observation point, and in this 2D feature space the ship-master will be able to interactively define a segmentation map, which is refined and optimized by the deformable template algorithms. The deformable templates are defined as two-dimensional vector-cycles. Local random transformations are applied to the vector-cycles, and stochastic relaxation in a Bayesian scheme is used. In the Bayesian likelihood a class density function and its estimate hereof is introduced, which is designed to separate the feature space. The method is verified on data collected in Øresund, Scandinavia. The data come from four geographically different areas. Two areas, which are homogeneous with respect to bottom type, are used for training of the deformable template classifier, and the classifier is applied to two areas, which are heterogeneous with respect to bottom type. The classification results are good with a correct classification percent above 94 per cent for the bottom type classes, and show that the deformable template classifier can be used for interactive on-line sea floor segmentation of RoxAnn echo sounder data.

A non-parametric 2D deformable template classifier

We introduce an interactive segmentation method for a sea floor survey. The method is based on a deformable template classifier and is developed to segment data from an echo sounder post-processor called RoxAnn. RoxAnn collects two different measures for each observation point, and in this 2D feature space the ship-master will be able to interactively define a segmentation map, which is refined and optimized by the deformable template algorithms. The deformable templates are defined as two-dimensional vector-cycles. Local random transformations are applied to the vector-cycles, and stochastic relaxation in a Bayesian scheme is used. In the Bayesian likelihood a class density function and its estimate hereof is introduced, which is designed to separate the feature space. The method is verified on data collected in Øresund, Scandinavia. The data come from four geographically different areas. Two areas, which are homogeneous with respect to bottom type, are used for training of the deformable template classifier, and the classifier is applied to two areas, which are heterogeneous with respect to bottom type. The classification results are good with a correct classification percent above 94 per cent for the bottom type classes, and show that the deformable template classifier can be used for interactive on-line sea floor segmentation of RoxAnn echo sounder data.
Change Detection for Remote Monitoring of Underground Nuclear Testing: Comparison with Seismic and Associated Explosion Source Phenomenological Data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Estimation of Critical Parameters in Concrete Production Using Multispectral Vision Technology

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Hansen, M. E. (Intern), Ersbøll, B. K. (Intern), Carstensen, J. M. (Intern), Nielsen, A. A. (Intern)
Pages: 1228-1237
Publication date: 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

Multi- and hyperspectral remote sensing change detection with generalized difference images by the IR-MAD method

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Canty, M. J. (Ekstern)
Publication date: 2005
Orthogonal transformations for change detection, Matlab code
Matlab code to do multivariate alteration detection (MAD) analysis, maximum autocorrelation factor (MAF) analysis, canonical correlation analysis (CCA) and principal component analysis (PCA) on image data.

Regularisation in multi- and hyperspectral remote sensing change detection

Sensitive change detection for remote sensing monitoring of nuclear treaties
Analysis of time-varying psoriasis lesion image patterns
The multivariate alteration detection transform is applied to pairs of within and between time varying registered psoriasis image patterns. Color band contribution to the variates explaining maximal change is analyzed.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Maletti, G. M. (Intern), Ersbøll, B. K. (Intern), Nielsen, A. A. (Intern), Gomez, D. D. (Intern)
Pages: 448-451
Publication date: 2004

Host publication information
Publisher: IEEE
ISBN (Print): 0-7803-8388-5
Main Research Area: Technical/natural sciences
Electronic versions:
imm3161.pdf
DOIs: 10.1109/ISBI.2004.1398571

Bibliographical note
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Source: orbit
Source-ID: 154639
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Automatic Radiometric Normalization of Multitemporal Satellite Imagery
The linear scale invariance of the multivariate alteration detection (MAD) transformation is used to obtain invariant pixels for automatic relative radiometric normalization of time series of multispectral data. Normalization by means of ordinary least squares regression method is compared with normalization using orthogonal regression. The procedure is applied to Landsat TM images over Nevada, Landsat ETM+ images over Morocco, and SPOT HRV images over Kenya. Results from this new automatic, combined MAD/orthogonal regression method, based on statistical analysis of test pixels not used in the actual normalization, compare favorably with results from normalization from manually obtained time-invariant features.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Canty, M. J. (Ekstern), Nielsen, A. A. (Intern), Schmidt, M. (Ekstern)
Pages: 441-451
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Remote Sensing of Environment
Volume: 91
Issue number: 3-4
ISSN (Print): 0034-4257
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
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<td>CiteScore 6.92, SJR 3.073, SNIP 2.943</td>
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Original language: English
Electronic versions: imm2815.pdf
DOIs: 10.1016/j.rse.2003.10.024
Source: orbit
Detection of buildings through multivariate analysis of spectral, textural, and shape based features
In recent publications, numerous methods for automated reconstruction/registration of buildings from stereo imagery have appeared (cf. e.g. Niederöst, 2003; Süweg, 2003). A common characteristic of these methods is the requirement of an existing approximate position (AP) of the building to be registered. In the present work, we develop a method for producing such APs based on sets of true colour (RGB) or colourinfrared (CIR) aerial imagery in combination with prior registrations from a GIS database. The primary intention with the work is to support the automated update of the GIS database. At the current stage of the project, the main goal is to produce a dataset where as much as possible of the "non building" area is masked out.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Knudsen, T. (Ekstern), Nielsen, A. A. (Intern)
Publication date: 2004

Host publication information
Title of host publication: International Geoscience and Remote Sensing Symposium (IGARSS)
Main Research Area: Technical/natural sciences
Electronic versions: imm3168.pdf
Links:
Source: orbit
Source-ID: 154627
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Geostatistik og analyse af spatielle data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Publication date: 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm3091.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3091
Source: orbit
Source-ID: 201125
Publication: Education › Compendium/lecture notes – Annual report year: 2004

Hyperspectral Data, Change Detection and the MAD Transformation
This paper deals with the application of the MAD transformation to change detection in bi-temporal hyperspectral data. Several processing schemes are proposed in order to facilitate both the actual change detection, the many variables involved and the spatial nature of the data.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Müller, A. (Ekstern), Dorigo, W. (Ekstern)
Pages: 683-688
Publication date: 2004

Host publication information
Title of host publication: 12th Australasian Remote Sensing and Photogrammetry Conference, Session keynote address
Main Research Area: Technical/natural sciences
Multi-set multi-temporal canonical analysis of psoriasis images

Nowadays, the medical tracking of dermatological diseases is imprecise, mainly due to the lack of suitable objective methods to evaluate the lesion. The severity of the disease is currently scored by doctors merely by means of visual examination. In this work, multi-set canonical correlation analysis over registered images is proposed to track the evolution of the disease automatically. This method transforms the original images into sets of variables that exhibit decreasing degree of similarity, based on correlation measures. Due to this property, these new variables are more suitable to detect where changes occur. An experiment with 5 different time series collected from psoriasis patients during 4 different sessions is conducted. The analysis of the obtained results points out some patterns that can be used both to interpret and summarize the evolution of the lesion and to achieve a better image registration.
Unsupervised classification of changes in multispectral satellite imagery
The statistical techniques of multivariate alteration detection, maximum autocorrelation factor transformation, expectation maximization, fuzzy maximum likelihood estimation and probabilistic label relaxation are combined in a unified scheme to classify changes in multispectral satellite data. An example involving bitemporal LANDSAT TM imagery is given.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Canty, M. J. (Ekstern), Nielsen, A. A. (Intern), Bruzzone, L. (ed.) (Ekstern)
Pages: 356-363
Publication date: 2004

Host publication information
Main Research Area: Technical/natural sciences
Electronic versions: imm3245.pdf
Source: orbit
Source-ID: 154604
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

A test statistic in the complex Wishart distribution and its application to change detection in polarimetric SAR data
When working with multilook fully polarimetric synthetic aperture radar (SAR) data, an appropriate way of representing the backscattered signal consists of the so-called covariance matrix. For each pixel, this is a 3 3 Hermitian positive definite matrix that follows a complex Wishart distribution. Based on this distribution, a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are derived and applied successfully to change detection in polarimetric SAR data. In a case study, EMISAR L-band data from April 17, 1998 and May 20, 1998 covering agricultural fields near Foulum, Denmark are used. Multilook full covariance matrix data, azimuthal symmetric data, covariance matrix diagonal-only data, and horizontal–horizontal (HH), vertical–vertical (VV), or horizontal–vertical (HV) data alone can be used. If applied to HH, VV, or HV data alone, the derived test statistic reduces to the well-known gamma likelihood-ratio test statistic. The derived test statistic and the associated significance value can be applied as a line or edge detector in fully polarimetric SAR data also.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Schou, J. (Intern), Skriver, H. (Intern)
Pages: 4-19
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Volume: 41
Issue number: 1
ISSN (Print): 0196-2892
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.29 SJR 2.461 SNIP 3.102
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.559 SNIP 3.241 CiteScore 4.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Finding the edges between different regions in an image is one of the fundamental steps of image analysis, and several edge detectors suitable for the special statistics of synthetic aperture radar (SAR) intensity images have previously been developed. In this paper, a new edge detector for polarimetric SAR images is presented using a newly developed test statistic in the complex Wishart distribution to test for equality of covariance matrices. The new edge detector can be applied to a wide range of SAR data from single-channel intensity data to multifrequency and/or multitemporal polarimetric radar applications, EMISAR, radar polarimetry, remote sensing change detection, covariance matrix test data.
SAR data. By simply changing the parameters characterizing the test statistic according to the applied SAR data, constant false-alarm rate detection is always obtained. An adaptive filtering scheme is presented, and the distributions of the detector are verified using simulated polarimetric SAR images. Using SAR data from the Danish airborne polarimetric SAR, EMISAR, it is demonstrated that superior edge detection results are obtained using polarimetric and/or multifrequency data compared to using only intensity data.

**General information**

State: Published  
Organisations: Department of Electromagnetic Systems, Microwaves and Remote Sensing, National Space Institute, Department of Informatics and Mathematical Modeling  
Authors: Schou, J. (Intern), Skriver, H. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)  
Pages: 20-32  
Publication date: 2003  
Main Research Area: Technical/natural sciences

**Publication information**

Volume: 41  
Issue number: 1  
ISSN (Print): 0196-2892  
Ratings:  
BFI (2018): BFI-level 2  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 2  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 2  
Scopus rating (2016): CiteScore 5.29 SJR 2.461 SNIP 3.102  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 2.559 SNIP 3.241 CiteScore 4.7  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 2.486 SNIP 3.582 CiteScore 4.71  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 2  
Scopus rating (2013): SJR 2.467 SNIP 3.355 CiteScore 4.22  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): SJR 2.382 SNIP 3.806 CiteScore 4.26  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): SJR 2.29 SNIP 3.049 CiteScore 3.85  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 2.082 SNIP 2.893  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 2.563 SNIP 3.064  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 2.38 SNIP 3.141  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 2.476 SNIP 3.858  
Web of Science (2007): Indexed yes
Change detection by the MAD method in hyperspectral image data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Muller, A. (Ekstern)
Publication date: 2003

Host publication information
Title of host publication: Abstracts from the 3rd EARSeL Workshop on Imaging Spectroscopy
Publisher: EARSeL
Main Research Area: Technical/natural sciences
Conference: 3rd EARSeL Workshop on Imaging Spectroscopy, Oberpfaffenhofen, May 13-16, 01/01/2003
Electronic versions:
imm2420.pdf
Links:
Source: orbit
Source-ID: 58585
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Evaluation of the Wishart Test Statistic for Polarimetric SAR Data

General information
State: Published
Organisations: Department of Electrical Engineering, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Skriver, H. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 2003
Evaluation of the Wishart test statistics for polarimetric SAR data

A test statistic for equality of two covariance matrices following the complex Wishart distribution has previously been used in new algorithms for change detection, edge detection and segmentation in polarimetric SAR images. Previously, the results for change detection and edge detection have been quantitatively evaluated. This paper deals with the evaluation of segmentation. A segmentation performance measure originally developed for single-channel SAR images has been extended to polarimetric SAR images, and used to evaluate segmentation for a merge-using-moment algorithm for polarimetric SAR data.

Polarimetric synthetic aperture radar data and the complex Wishart distribution

When working with multi-look fully polarimetric synthetic aperture radar (SAR) data an appropriate way of representing the backscattered signal consists of the so-called covariance matrix. For each pixel this is a 3 by 3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are given and applied to segmentation, change detection and edge detection in polarimetric SAR data. In a case study EMISAR L-band data from 17 April 1998 and 20 May 1998 covering agricultural fields near Foulum, Denmark, are used.
Exploratory Analysis of Multivariate Data (Unsupervised Image Segmentation and Data Driven Linear and Nonlinear Decomposition)

This work describes different methods that are useful in the analysis of multivariate single and multiset data. The thesis covers selected aspects of relevant data analysis techniques in this context. Methods dedicated to handling data of a spatial nature are of primary interest with focus on data driven exploratory methods for i) clustering, and for both ii) linear and iii) nonlinear decompositioning. New extensions are presented in all three fields.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, DTU Data Analysis, Image Analysis and Computer Graphics
Authors: Hilger, K. B. (Intern), Ersbøll, B. K. (Intern), Nielsen, A. A. (Intern)
Publication date: Mar 2002

A Bivariate Extension to Traditional Empirical Orthogonal Function Analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Hilger, K. B. (Intern), Andersen, O. B. (Ekstern), Knudsen, P. (Ekstern)
Pages: 179-185
Publication date: 2002

A Change Oriented Extension of EOF Analysis Applied to the 1996-1997 AVHRR Sea Surface Temperature Data

This paper describes the application of orthogonal transformations to detect multivariate change in the monthly mean sea surface temperature (SST) as given by the NOAA/NASA Oceans Pathfinder data. The transforms applied include multivariate alteration detection (MAD) variates based on canonical correlation analysis, and maximum autocorrelation
factors (MAFs). The method described can be considered as an extension to EOF analysis that is specially tailored for change detection in spatial data since it first maximises differences in the data between two points in time and then maximises autocorrelation between neighbouring observations. The results show that the large scale ocean events associated with the El Nino/Southern Oscillation (ENSO) related changes are concentrated in the first SST MAF/MAD mode and the two first SSH MAF/MAD modes. The MAD/MAF analysis also revealed a spatially correlated structure in the Western Mediterranean Sea that turned out to be related to a strong semi-annual variation in the SST for 1997 which was difficult to resolve from a traditional principal component analysis.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Andersen, O. B. (Ekstern), Plag, H. (ed.) (Ekstern)
Pages: 1379-1386
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Physics and Chemistry of the Earth (Print)
Volume: 27
Issue number: 32-34
ISSN (Print): 1474-7065
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 0.378 SNIP 0.793 CiteScore 1.3
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.684 SNIP 1.262 CiteScore 1.66
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.852 SNIP 1.264 CiteScore 1.83
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.697 SNIP 0.998 CiteScore 1.65
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.51 SNIP 0.866 CiteScore 1.19
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.603 SNIP 0.953 CiteScore 1.37
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.621 SNIP 0.879
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.59 SNIP 0.959
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.757 SNIP 1.021
Scopus rating (2007): SJR 0.744 SNIP 0.953
Scopus rating (2006): SJR 0.653 SNIP 1.038
Scopus rating (2005): SJR 0.804 SNIP 1.101
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.425 SNIP 0.806
Scopus rating (2003): SJR 0.276 SNIP 0.585
Web of Science (2003): Indexed yes
A Temporal Extension to Traditional Empirical Orthogonal Function Analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Hilger, K. B. (Intern), Andersen, O. B. (Ekstern), Knudsen, P. (Ekstern), Bruzzone et al., L. (ed.) (Ekstern)
Pages: 164-170
Publication date: 2002

Host publication information
Title of host publication: Analysis of Multi-Temporal Remote Sensing Images (MultiTemp2001, Trento, Italy)
Publisher: World Scientific
Main Research Area: Technical/natural sciences
Electronic versions: imm289.pdf
Source: orbit
Source-ID: 58199
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Linear and Nonlinear Multiset Canonical Correlation Analysis (invited talk)
This paper deals with decomposition 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.

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), Conradsen, K. (Intern)
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
Electronic versions: imm912.pdf
Source: orbit
Source-ID: 58180
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Multiset Canonical Correlations Analysis and Multispectral, Truly Multitemporal Remote Sensing Data
This paper describes two- and multiset canonical correlations analysis (CCA) for data fusion, multi-source, multiset or multi-temporal exploratory data analysis. These techniques transform multivariate multiset data into new orthogonal
variables called canonical variates (CVs) which when applied in remote sensing exhibit ever decreasing similarity (as expressed by correlation measures) over sets consisting of 1) spectral variables at fixed points in time (R-mode analysis), or 2) temporal variables with fixed wavelengths (T-mode analysis). The CVs are invariant to linear and affine transformations of the original variables within sets which means, for example, that the R-mode CVs are insensitive to changes over time in offset and gain in a measuring device. In a case study CVs are calculated from Landsat TM data with six spectral bands over six consecutive years. Both R- and T-mode CVs clearly exhibit the desired characteristic: they show maximum similarity for the low order canonical variates and minimum similarity for the high order canonical variates. These characteristics are seen both visually and in objective measures. The results from the multiset CCA R- and T-mode analyses are very different. This difference is ascribed to the noise structure in the data. The CCA methods are related to partial least squares (PLS) methods. The paper very briefly describes multiset CCA based multiset PLS. Also, the CCA methods can be applied as multivariate extensions to empirical orthogonal functions (EOF) techniques. (Multiset) CCA is well suited for inclusion in geographical information systems, GIS.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Pages: 293-305
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Image Processing
Volume: 11
Issue number: 3
ISSN (Print): 1057-7149
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 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
Scopus rating (2013): SJR 1.67 SNIP 4.537 CiteScore 6.14
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.698 SNIP 4.694 CiteScore 5.58
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.735 SNIP 3.983 CiteScore 5.04
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.939 SNIP 4.18
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.299 SNIP 4.318
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.179 SNIP 3.856
Polarimetric Segmentation Using Wishart Test Statistic

A newly developed test statistic for equality of two complex covariance matrices following the complex Wishart distribution and an associated asymptotic probability for the test statistic has been used in a segmentation algorithm. The segmentation algorithm is based on the MUM (merge using moments) approach, which is a merging algorithm for single channel SAR images. The polarimetric version described in this paper uses the above-mentioned test statistic for merging. The segmentation algorithm has been applied to polarimetric SAR data from the Danish dual-frequency, airborne polarimetric SAR, EMISAR. The results show clearly an improved segmentation performance for the full polarimetric algorithm compared to single channel approaches.
Simultaneous maximization of spatial and temporal autocorrelation in spatio-temporal data

Based on Switzer and Green's maximum autocorrelation factor (MAF) analysis for multivariate image data an extension for spatio-temporal data is suggested. Traditional MAF analysis generates new orthogonal variates from the original multivariate image data by maximizing spatial autocorrelation. This is done by solving the generalized eigenproblem represented by the Rayleigh coefficient where is the dispersion of and is the dispersion of the difference between and spatially shifted. Hence, the new variates are obtained from the conjugate eigenvectors and the autocorrelations obtained are, i.e., high autocorrelations are associated with small eigenvalues and vice versa. Often is calculated by means of a pool of a horizontal and a vertical shift. If the data are not spatial but temporal the spatial shift is replaced by a temporal shift causing the temporal autocorrelation to be maximized. Such a temporal MAF analysis is equivalent to Molgedey and Schuster's method for calculating independent components of temporal data. If the data are both spatial and temporal it is suggested here to calculate by pooling both spatial and temporal shifts. Results from such a simultaneous maximization of spatial and temporal autocorrelation on two years of global monthly mean sea surface temperature and sea surface height anomaly data are compared with results from 1) maximization of temporal autocorrelation alone, 2) maximization of spatial autocorrelation alone, and 3) so-called empirical orthogonal function (EOF) analysis which is traditionally used in oceanography and which is equivalent to principal component analysis.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Eleventh International Workshop on Matrices and Statistics, invited, Lyngby, Denmark, 29-31 August: Book of abstracts
Main Research Area: Technical/natural sciences
Electronic versions:
imm928.pdf
Links:
Source: orbit
Source-ID: 58194

Spatio-temporal analysis including multi-objective orthogonalisation and independent component analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Number of pages: 26
Publication date: 2002

Host publication information
Title of host publication: Invited keynote address to the International Conference of the Royal Statistical Society: Book of abstracts
Main Research Area: Technical/natural sciences
Conference: Invited keynote address to the International Conference of the Royal Statistical Society, 01/01/2002
Electronic versions:
imm927.pdf
Links:
Source: orbit
Source-ID: 58257

An ACE-based Nonlinear Extension to Traditional Empirical Orthogonal Function Analysis

This paper shows the application of the empirical orthogonal functions/principal component transformation on global sea surface height and temperature data from 1996 and 1997. A nonlinear correlation analysis of the transformed data is proposed and performed by applying the alternating conditional expectations algorithm. New canonical variates are found that indicate that the highest correlation between ocean temperature and height is associated with the build-up of the El Niño during the last half of 1997.
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.

Bio-optical Modelling: DECO Data Report

Change detection in polarimetric SAR data and the complex Wishart distribution

When working with multi-look fully polarimetric synthetic aperture radar (SAR) data an appropriate way of representing the backscattered signal consists of the so-called covariance matrix. For each pixel this is a 3×3 Hermitian, positive definite matrix which follows a complex Wishart distribution. Based on this distribution a test statistic for equality of two such
matrices and an associated asymptotic probability for obtaining a smaller value of the test statistic are given and applied to change detection in polarimetric SAR data. In a case study EMISAR L-band data from 17 April 1998 and 20 May 1998 covering agricultural fields near Foulum, Denmark are used. The derived test statistic can be applied as a line or edge detector in fully polarimetric SAR data also.

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Department of Electromagnetic Systems
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Schou, J. (Intern), Skriver, H. (Intern)
Publication date: 2001

**Host publication information**
Title of host publication: Proceedings of the IEEE 2001 International Geoscience and Remote Sensing Symposium
Volume: 6
ISBN (Print): 0-7803-7031-7
Main Research Area: Technical/natural sciences
Electronic versions:
conradsen.pdf
DOIs:
10.1109/IGARSS.2001.978111

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Source: orbit
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

**Change Detection in the 1996-1997 AVHRR Oceans Pathfinder Sea Surface Temperature Data**

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Andersen, O. B. (Ekstern), Austvoll, I. (ed.) (Ekstern)
Pages: 717-724
Publication date: 2001

**Host publication information**
Title of host publication: Proceedings of 12th Scandinavian Conference on Image Analysis (SCIA 2001)
Main Research Area: Technical/natural sciences
Electronic versions:
imm294.pdf
Links:
Source: orbit
Source-ID: 57860
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

**El Niño Build-up Detection by Means of Canonical Correlations in the 1996-1997 SST and SSH Data**

**General information**
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Andersen, O. B. (Ekstern)
Number of pages: 1,801
Publication date: 2001

**Host publication information**
Title of host publication: Geophysical Research Abstracts, European Geophysical Society, EGS2001, XXVI General Assembly
Polarimetric Edge Detector Based on the Complex Wishart Distribution
A new edge detector for polarimetric SAR data has been developed. The edge detector is based on a newly developed test statistic for equality of two complex covariance matrices following the complex Wishart distribution and an associated asymptotic probability for the test statistic. The new polarimetric edge detector provides a constant false alarm rate and it utilizes the full polarimetric information. The edge detector has been applied to polarimetric SAR data from the Danish dual-frequency, airborne polarimetric SAR, EMISAR. The results show clearly an improved edge detection performance for the full polarimetric detector compared to single channel approaches.

Simultaneous Determination of Water Constituent Concentrations and Partial Least Squares

Copyright: 2000 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
Spectral Mixture Analysis: Linear and Semi-parametric Full and Iterated Partial Unmixing in Multi- and Hyperspectral Image Data

As a supplement or an alternative to classification of hyperspectral image data linear and semi-parametric mixture models are considered in order to obtain estimates of abundance of each class or end-member in pixels with mixed membership. Full unmixing based on both ordinary least squares (OLS) and non-negative least squares (NNLS), and the partial unmixing methods orthogonal subspace projection (OSP), constrained energy minimization (CEM) and an eigenvalue formulation alternative are dealt with. The solution to the eigenvalue formulation alternative proves to be identical to the CEM solution. The matrix inversion involved in CEM can be avoided by working on (a subset of) orthogonally transformed data such as signal maximum autocorrelation factors, MAFs, or signal minimum noise fractions, MNFs. This will also cause the partial unmixing result to be independent of the noise isolated in the MAF/MNFs not included in the analysis. CEM and the eigenvalue formulation alternative enable us to perform partial unmixing when we know one desired end-member spectrum only and not the full set of end-member spectra. This is an advantage over full unmixing and OSP. The eigenvalue formulation of CEM inspires us to suggest an iterated CEM scheme. Also the target constrained interference minimized filter (TCIMF) is described. Spectral angle mapping (SAM) is briefly described. Finally, semi-parametric unmixing (SPU) based on a combined linear and additive model with a non-linear, smooth function to represent end-member spectra unaccounted for is introduced. An example with two generated bands shows that both full unmixing, the CEM, the iterated CEM and TCIMF methods perform well. A case study with a 30 bands subset of AVIRIS data shows the utility of full unmixing, SAM, CEM and iterated CEM to more realistic data. Iterated CEM seems to suppress noise better than CEM. A study with AVIRIS spectra generated from real spectra shows (1) that ordinary least squares in this case with one unknown spectrum performs better than non-negative least squares, and (2) that although not fully satisfactory the semi-parametric model gives better estimates of end-member abundances than the linear model.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Pages: 17-37
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Mathematical Imaging and Vision
Volume: 15
Issue number: 1-2
ISSN (Print): 0924-9907
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 0.846 SNIP 1.503 CiteScore 2.08
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.757 SNIP 1.532 CiteScore 1.72
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.127 SNIP 2.157 CiteScore 2.82
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.039 SNIP 2.535 CiteScore 3.04
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.992 SNIP 2.157 CiteScore 2.57
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.883 SNIP 1.718 CiteScore 1.87
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.907 SNIP 1.74
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.182 SNIP 1.889
BFI (2008): BFI-level 2
Spectral Mixture Analysis: Linear and Semi-parametric Full and Iterated Partial Unmixing in Multi- and Hyperspectral Image Data.

As a supplement or an alternative to classification of hyperspectral image data linear and semi-parametric mixture models are considered in order to obtain estimates of abundance of each class or end-member in pixels with mixed membership. Full unmixing based on both ordinary least squares (OLS) and non-negative least squares (NNLS), and the partial unmixing methods orthogonal subspace projection (OSP), constrained energy minimization (CEM) and an eigenvalue formulation alternative are dealt with. The solution to the eigenvalue formulation alternative proves to be identical to the CEM solution. The matrix inversion involved in CEM can be avoided by working on (a subset of) orthogonally transformed data such as signal maximum autocorrelation factors, MAFs, or signal minimum noise fractions, MNFs. This will also cause the partial unmixing result to be independent of the noise isolated in the MAF/MNFs not included in the analysis. CEM and the eigenvalue formulation alternative enable us to perform partial unmixing when we know one desired end-member spectrum only and not the full set of end-member spectra. This is an advantage over full unmixing and OSP. The eigenvalue formulation of CEM inspires us to suggest an iterated CEM scheme. Also the target constrained interference minimized filter (TCIMF) is described. Spectral angle mapping (SAM) is briefly described. Finally, semi-parametric unmixing (SPU) based on a combined linear and additive model with a non-linear, smooth function to represent end-member spectra unaccounted for is introduced. An example with two generated bands shows that both full unmixing, the CEM, the iterated CEM and TCIMF methods perform well. A case study with a 30 bands subset of AVIRIS data shows the utility of full unmixing, SAM, CEM and iterated CEM to more realistic data. Iterated CEM seems to suppress noise better than CEM. A study with AVIRIS spectra generated from real spectra shows (1) that ordinary least squares in this case with one unknown spectrum performs better than non-negative least squares, and (2) that although not fully satisfactory the semi-parametric model gives better estimates of end-member abundances than the linear model.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Pages: 17-37
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Computer Vision
Volume: 42
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ISSN (Print): 0920-5691
Ratings:
BFI (2018): 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
A multivariate approach to seismic 4D analysis, Troll West Oil Province (2)

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

Aspects of remote sensing of the GEOid and Sea level Of the North Atlantic Region (GEOSONAR) project

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), Knudsen, P. (EKstern)
Publication date: 2000
Event: Poster session presented at Danish ocean researchers’ meeting, Roskilde, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 201244
Publication: Research › Poster – Annual report year: 2000

Enhancement of Ocean Related Signal by Suppression of Undesired Spectra in Remotely Sensed Multivariate SeaWiFS Images in the GEOSONAR Project

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), Knudsen, P. (EKstern), Andersen, O. B. (EKstern)
Publication date: 2000

Host publication information
Title of host publication: American Geophysical Union (AGU) Fall Meeting
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176487
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Maximum Autocorrelation Factorial Kriging
This paper describes maximum autocorrelation factor (MAF) analysis, maximum autocorrelation factorial kriging, and its application to irregularly sampled stream sediment geochemical data from South Greenland. Kriged MAF images are compared with kriged images of varimax rotated factors from an ordinary non-spatial factor analysis, and they are interpreted in a geological context. It is demonstrated that MAF analysis contrary to ordinary non-spatial factor analysis gives an objective discrimination of largescale as well as small-scale geological features which are related to crustal structure and the occurrence of specific rock types.

General information
New approaches for change detection studies

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.

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.
Spectral identification of plant communities for mapping of semi-natural grasslands

The study was performed on Danish grasslands on well-drained sandy soils. Image data included georeferenced Compact Airborne Spectrographic Imager (casi) data calibrated to apparent surface reflectance. Ecological data included a field-based management map, registration of (vascular) plant species and thirty 30 m by 30 m test sites with affinities seven management classes identified in the field and seven floristic classes modelled from detrended correspondence analysis. Spectral analysis was performed on the derived image reflectance of 18 test sites positioned within the casi scanline. Spectral identification of plant communities was based on a hierarchical approach relating the test sites to i) management (Ma) and ii) flora (Fi) using spectral consistency and separability as the main criteria. Evaluation of spectral consistency was based on unsupervised clustering of test sites of Ma classes 1 to 7 followed by canonical discriminant analysis. Evaluation of spectral separability was based on measures of the Jeffries-Matusita distance. Seed growing generated training classes relating to management and flora (MaFl classes). Maximum likelihood classification showed that the classes were well-defined in statistical terms and also spatially coherent. Superimposition of the classification of MaFl classes on the management map added detailed information of vegetation variation within the management areas. The inverse of the classification accuracy, using the management map as ‘ground truth’, was interpreted as a measure of plant community heterogeneity within management classes. The spectral analysis as well as the maximum likelihood classification indicated that the source of spectral variation within management classes might be related to vegetation composition.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Jacobsen, A. (Ekstern), Nielsen, A. A. (Intern), Ejrnæs, R. (Ekstern), Groom, G. B. (Ekstern)
Pages: 370-383
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Canadian Journal of Remote Sensing
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.67 SJR 0.712 SNIP 0.761
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.868 SNIP 0.753 CiteScore 1.95
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.93 SNIP 1.099 CiteScore 1.53
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.855 SNIP 1.113 CiteScore 1.42
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.68 SNIP 0.91 CiteScore 1.04
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.634 SNIP 0.664 CiteScore 0.95
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.593 SNIP 0.608
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.759 SNIP 0.523
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.839 SNIP 1.436
Scopus rating (2007): SJR 0.797 SNIP 1.305
Scopus rating (2006): SJR 1.46 SNIP 1.094
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.

Targeting input data for change detection studies by suppression of undesired spectra
Unsupervised classification of x-ray mapping images of polished section

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), Carstensen, J. M. (Intern)
Pages: 44-47
Publication date: 2000

Host publication information
Title of host publication: Proceedings of MVA2000, IAPR Workshop on Machine Vision Applications
Main Research Area: Technical/natural sciences
Electronic versions:
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Source: orbit
Source-ID: 200146
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Unsupervised Fuzzy Clustering of Multivariate Image Data

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)
Publication date: 2000
Event: Poster session presented at Danish ocean researchers' meeting, Roskilde, Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
imm181.zip
imm181.pdf
Source: orbit
Source-ID: 201204
Publication: Research › Poster – Annual report year: 2000

An Extension to a Filter Implementation of Local Quadratic Surface for Image Noise Estimation

Based on regression analysis this paper gives a description for simple image filter design. Specifically 3x3 filter implementations of a quadratic surface, residuals from this surface, gradients and the Laplacian are given. For the residual a 5x5 filter is given also. It is shown that the 3x3 filter for the residual gives low values for horizontal and vertical lines and edges as opposed to diagonal ones. Therefore an extension including a rotated version of the filter for the residual to ensure low values for lines and edges in all directions is suggested. It is also shown that the 5x5 filter for the residual does not give low values for lines and edges in any direction. The performance of six noise models including the ones mentioned above are compared. Based on visual inspection of results from an example using a generated image (with all directions and many spatial frequencies represented) it is concluded that if striping is to be considered as a part of the noise, the residual from a 3x3 median filter seems best. If we are interested in a salt-and-pepper noise estimator the
The proposed extension to the 3x3 filter for the residual from a quadratic surface seems best. Simple statistics and autocorrelations in the estimated noise images support these findings.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Pages: 119-124
Publication date: 1999

Host publication information
Title of host publication: 10th International Conference on Image Analysis and Processing, ICIAP'99.
Main Research Area: Technical/natural sciences
Conference: 10th International Conference on Image Analysis and Processing, ICIAP'99., 01/01/1999
Electronic versions:
imm3937.pdf
Source: orbit
Source-ID: 200248
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Aspects of Remote Sensing in the GEOid and Sea level Of the North Atlantic Region (GEOSONAR) Project
The general objectives of the GEOid and Sea level Of the North Atlantic Region (GEOSONAR) project are presented. These include analyses of the dynamics of the ocean and its characteristics. The analyses are mainly based on remote sensing. As an example a data set obtained by the multi-channel Sea-viewing Wide Field-of-view Sensor (SeaWiFs) is analysed. The presentation results include the computed principal components (PC) and the maximum autocorrelation factors (MAF). Both methods are expected to be incorporated into future analyses of the state of the ocean.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, National Survey and Cadastre
Authors: Hilger, K. B. (Intern), Nielsen, A. A. (Intern), Knudsen, P. (Ekstern)
Pages: 881-888
Publication date: 1999

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Title of host publication: Proceedings of The 11th Scandinavian Conference on Image Analysis
Place of publication: Lyngby
Main Research Area: Technical/natural sciences
Conference: 11th Scandinavian Conference on Image Analysis (SCIA), Kangerlussuaq, Greenland, 07/06/1999 - 07/06/1999
Source: orbit
Source-ID: 172438
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Classification of Minerals by EDS Images from a Hitachi S-3000N Low Vacuum SEM.

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: 1999

Publication information
Publisher: IMM Publications
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200907
Publication: Research - peer-review › Report – Annual report year: 1999

Computerised image analysis of biocrystallograms originating from agricultural products
Procedures are presented for computerised image analysis of biocrystallogram images, originating from biocrystallization investigations of agricultural products. The biocrystallization method is based on the crystallographic phenomenon that when adding biological substances, such as plant extracts, to aqueous solutions of dihydrate CuCl2, biocrystallograms
with reproducible dendritic crystal structures are formed during crystallisation. The morphological features found in the structures are traditionally applied for visual ranking or classification, e.g. in comparative studies of the effects of farming systems on crop quality. The circular structures contain predominantly a single centre from where ramifications expand in a zonal structure. In previous studies primarily texture analysis was applied, and the images analysed and classified by means of a circular region-of-interest (ROI), i.e., the region specified for analysis. In the present study the objective was to examine how the discriminative information relevant for classification purposes is distributed over the zonal structure, and how the information is affected by the varying location of the crystallisation centre. The texture analysis procedures were applied to a so-called degradation series of 33 images, including seven groups representing discrete `treatment levels’.

The biocrystallograms were produced over seven consecutive days, on the basis of a single carrot extract degrading while stored at 6°C. This degradation is known to induce systematic changes in morphological features over a number of successive days. The biocrystallograms were scanned at 600 dpi, with 256 grey levels. Eight first-order statistical parameters were calculated for four resolution scales, and 15 second-order parameters for five scales, giving a total of 107 observations for each image. Classification of an individual image was performed by means of stepwise discriminant analysis. Four main types, and several subtypes and sizes of ROI were examined. The 33 images as well as a subset of 21 images were examined. When imposing a restriction on the centre location in the subset, thereby reducing the within-group variance, the scores were markedly improved. Classifications of the total set and the subset showed scores up to 84.8 and 100%, respectively. A number of parameters showed a monotonic relationship with degradation day number. Multiple linear regressions based on up to eight parameters indicated strong relationships, with R² up to 0.98. It is concluded that the procedures were able to discriminate the seven groups of images, and are applicable for biocrystallization investigations of agricultural products. Perspectives for the application of image analysis are briefly mentioned.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Andersen, J. (Ekstern), Henriksen, C. B. (Ekstern), Laursen, J. (Ekstern), Nielsen, A. A. (Intern)
Pages: 51-69
Publication date: 1999
Main Research Area: Technical/natural sciences

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Journal: Computers and Electronics in Agriculture
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.896 SNIP 1.836 CiteScore 3.27
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.819 SNIP 1.909 CiteScore 2.99
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.976 SNIP 2.128 CiteScore 2.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.968 SNIP 2.384 CiteScore 2.89
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.089 SNIP 2.162 CiteScore 2.86
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.077 SNIP 2.245 CiteScore 3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.663 SNIP 1.694
Web of Science (2010): Indexed yes
GEOSONAR: Mid-Term Report (2nd Annual Report)

Geostatistik og analyse af spatielle data

GIS In Denmark 2: Geostatistics and Analysis of Spatial Data

Linear Mixture Models, Full and partial Unmixing in Multi-and Hyperspectral Image Data.

General information
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Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Publication date: 1999

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Publisher: Springer Verlag
Original language: English
Main Research Area: Technical/natural sciences
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Orthogonal Transformations: Lecture note

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Number of pages: 8
Publication date: 1999

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm3088.pdf
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http://www2.imm.dtu.dk/pubdb/p.php?3088
Source: orbit
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Publication: Education › Compendium/lecture notes – Annual report year: 1999

Partial unmixing in hyperspectral image data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Pages: 535-542
Publication date: 1999

Host publication information
Title of host publication: Proceedings of the Fourth International Airborne Remote Sensing Conference and Exhibition
Main Research Area: Technical/natural sciences
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.
Spectral identification of Danish grassland related management and plant species composition

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, National Environmental Research Institute
Authors: Jabobsen, A. (Ekstern), Nielsen, A. A. (Intern), Ejrnæs, R. (Ekstern), Groom, G. (Ekstern)
Pages: 74-81
Publication date: 1999

Host publication information
Title of host publication: Proceedings of The fourth International Airborne Remote Sensing Conference and Exhibition/21st Canadian Symposium on Remote Sensing
Main Research Area: Technical/natural sciences
Conference: The fourth International Airborne Remote Sensing Conference and Exhibition/21st Canadian Symposium on Remote Sensing, Ottawa, Ontario, Canada, 01/01/1999
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Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Transformations of SeaWiFS data: GEOSONAR Data Report no. 1

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Hilger, K. B. (Intern), Nielsen, A. A. (Intern)
Publication date: 1999

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172439
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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

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), Erbsbøll, B. K. (Intern), Larsen, R. (Intern), Nielsen, A. A. (Intern), Nielsen, T. H. (Ekstern)
Pages: 25-30
Publication date: 1998
Linear Mixture Models and Partial Unmixing in Multi- and Hyperspectral Image Data

As a supplement or an alternative to classification of hyperspectral image data the linear mixture model is considered in order to obtain estimates of abundance of each class or end-member in pixels with mixed membership. Full unmixing and the partial unmixing methods orthogonal subspace projection (OSP), constrained energy minimization (CEM) and an eigenvalue formulation alternative are dealt with. The solution to the eigenvalue formulation alternative proves to be identical to the CEM solution. The matrix inversion involved in CEM can be avoided by working on (a subset of) orthogonally transformed data such as signal maximum autocorrelation factors, MAFs, or signal minimum noise fractions, MNFs. This will also cause the noise isolated in the MAF/MNFs not included in the analysis not to influence the partial unmixing result. CEM and the eigenvalue formulation alternative enable us to perform partial unmixing when we know the desired end-member spectra only and not the full set of end-member spectra. This is an advantage over full unmixing and OSP. An example with a simple simulated 2-band image shows the ability of the CEM method to isolate the desired signal. A case study with a 30 bands subset of AVIRIS data from the Mojave Desert, California, USA, indicates the utility of CEM to more realistic data.
Multivariate Alteration Detection (MAD) and MAF Postprocessing in Multispectral, Bitemporal Image Data: New Approaches to Change Detection Studies

This article introduces the multivariate alteration detection (MAD) transformation which is based on the established canonical correlations analysis. It also proposes using postprocessing of the change detected by the MAD variates using maximum autocorrelation factor (MAF) analysis. The MAD and the combined MAD/MAF transformations are invariant to linear scaling. Therefore, they are insensitive, for example, to differences in gain settings in a measuring device, or to linear radiometric and atmospheric correction schemes. Other multivariate change detection schemes described are principal component type analyses of simple difference images. Case studies with AVHRR and Landsat MSS data using simple linear stretching and masking of the change images show the usefulness of the new MAD and MAD/MAF change detection schemes. Ground truth observations confirm the detected changes. A simple simulation of a no-change situation shows the accuracy of the MAD and MAD/MAF transformations compared to principal components based methods.
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.

Analyses of Spectral-Biophysical Relationships for a Wheat Canopy.

An Application of Discriminant Analysis to Pattern Recognition of Selected Contaminated Soil Features in Thin Sections

A soil contaminated with copper, chromium and arsenic from an industrial site was characterized with respect to heavy metal (Cu, Cr) and metalloid (As) total content, and for metal speciation by sequential chemical extraction. The contaminated soil contained a negligible proportion of Cu, As and Cr in the soluble and exchangeable phase, these elements being associated primarily with amorphous-crystalline Fe-oxides, organic matter and/or resistant phases. The results obtained with sequential extraction were the prerequisite to the attempt to identify the Cr and As distribution in the solid phase. If high concentrations of contaminants are indicated by chemical wet analysis, these contaminants must occur directly in the solid phase. Thin sections of soil aggregates were scanned for Cu, Cr and As using an electron microprobe, and qualitative analysis was made on selected areas. Microphotographs of thin sections of domains (or parts of them), obtained with plane polarized light, and which the electron microprobe showed to be of interest, were saved on a Kodak photo CD. These relevant identified soil features were shown to be iron-aluminium-silicon, which always had a yellowish colour and showed the common qualitative microprobe results: present elements Al, Si, Cr, Fe, As (associated with others). Selected groups of calibrated images (same light conditions and magnification) submitted to discriminant analysis, in order to find a pattern of recognition in the soil features corresponding to contamination already identified in the thin sections. The authors present a procedure to study the spatial distribution of contaminants in images of contaminated soil features taken from thin sections.
Application of Image Processing: Techniques and Geostatistical Methods to the Aerial Gamma-Ray Spectrometric and Aeromagnetic Survey Data of Wadi Al Miah - Wadi Ash Shalul, Central Eastern Desert, Egypt as an Aid to Geological Mapping and Mineral Exploration

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Nuclear Materials Authority
Authors: Ersbøll, B. K. (Intern), Mahmoud, S. M. (Ekstern), Nielsen, A. A. (Intern)
Number of pages: 49
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
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Source-ID: 168678
Publication: Research - peer-review › Report – Annual report year: 1997

A Simple Neural Network Contextual Classifier

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Tidemann, J. (Ekstern)
Pages: 186-193
Publication date: 1997

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Title of host publication: Neurocomputation in Remote Sensing Data Analysis
Place of publication: Berlin
Publisher: Springer Verlag
Main Research Area: Technical/natural sciences
Conference: COMPARES work shop, York, England, 01/01/1997
Source: orbit
Source-ID: 168596
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

casi Scanner Test Data

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

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200949
Publication: Research - peer-review › Report – Annual report year: 1997

Change Detection in Bi-temporal EMISAR Data from Kalø, Denmark, by Means of Canonical Correlations Analysis

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Electromagnetic Systems, Department of Electrical Engineering
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Skriver, H. (Intern), ERIM, E. R. I. O. M. (ed.) (Ekstern)
Pages: 281-287
Publication date: 1997
Classification of EMISAR C-band Data: M17/M25: DANMAC Data Report.

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

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200990
Publication: Research - peer-review › Report – Annual report year: 1997

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.

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: 200908
Publication: Research - peer-review › Report – Annual report year: 1997
Multivariate Alteration Detection (MAD) in Multispectral, Bi-temporal Image Data: A New Approach to Change Detection Studies.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Number of pages: 46
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 168581
Publication: Research - peer-review › Report – Annual report year: 1997

Multivariate alteration detection (MAD) in multispectral, bi-temporal image data: A new approach to change detection studies
This paper introduces a new orthogonal transformation, the multivariate alteration detection (MAD) transformation, based on an established multivariate statistical technique canonical correlation analysis. The theory for canonical correlation analysis is sketched and a result necessary for the definition of the MAD transformation is proven. As opposed to traditional univariate change detection schemes our scheme transforms two sets of multivariate observations (e.g. two multispectral satellite images covering the same geographical area acquired at different points in time) into a difference between two linear combinations of the original variables explaining maximal change (i.e. the difference explaining maximal variance) in all variables simultaneously. The MAD transformation is invariant to linear scaling. The MAD transformation can be used iteratively. First, it can be used to detect outliers (such as drop-outs) or noise and in a second iteration, it can be used to perform the actual change detection after appropriate action on outliers or noise. Also, if an analyst has additional information such as geographical position of certain changes of interest that show up in certain bands only, our method can be applied to any spatial and/or spectral subset of the full data set to direct the analysis in any desired manner. In order to obtain a spatially more coherent representation of the detected change as obtained from the MAD analysis, post-processing by means of a minimum/maximum autocorrelation factor (MAF) transformation of the MAD variates can be performed. Whereas the traditionally used principal component (PC) transformation optimizes the data variance in each new component the MAF transformation optimizes the autocorrelation represented by each component. This post-processing introduces a new spatial element into our change detection scheme which is highly relevant for image data. Two case studies using multispectral SPOT HRV data from 5 February 1987 and 12 February 1989 covering coffee and pineapple plantations in central Kenya, and Landsat TM data from 6 June 1986 and 27 June 1988 covering a forested region in northern Sweden show the usefulness of these new concepts. Because of their ability to detect change in many channels simultaneously, the MAD transformation and the MAF post-processing are expected to be even more useful when applied to image data with more bands.

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

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

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1997
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. Striping 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.
Spatial analysis of multivariate, (ir-)regularly sampled data: Geochemistry of the eastern Erzgebirge

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Erbsøll, B. K. (Intern), Pålchen, W. (Ekstern), Baafi, E. (ed.) (Ekstern), Scofield, N. (ed.) (Ekstern)
Pages: 1173-1184
Publication date: 1997

Host publication information
Title of host publication: Proceedings of the 5th International Geostatistics Congress. Wollongong, 22-27 September 1996
Publisher: Kluwer Academic Publishers
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200254
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Spatial Factor Analysis of Stream Sediment Geochemistry Data from South Greenland.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Conradsen, K. (Intern), Pedersen, J. L. (Ekstern), Steenfelt, A. (Ekstern)
Pages: 955-960
Publication date: 1997

Host publication information
Title of host publication: Proceedings of the Third Annual Conference of the International Association for Mathematical Geology
Place of publication: Barcelona
Publisher: Glahn, Vera Pawlowsky (ed.)
Main Research Area: Technical/natural sciences
Conference: Third Annual Conference of the International Association for Mathematical Geology, IAMG, Barcelona, Spain, 01/01/1997
Source: orbit
Source-ID: 168592
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

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)
Publication date: 1996

Publication information
Publisher: IMM Publications
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200910
Publication: Research - peer-review › Report – Annual report year: 1996

Crop Variability Mapping Using Multispectral Data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Broge, N. (Ekstern), Hvidberg, M. (Ekstern), Hansen, B. (Ekstern), Andersen, H. (Ekstern)
Publication date: 1996
DAIS System Performance, First Results from the 1995 Evaluation Campaigns

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Strobl, P. (Ekstern), Richter, R. (Ekstern), Muller, A. (Ekstern), Lehmann, F. (Ekstern), Oertel, D. (Ekstern), Tischler, S. (Ekstern)
Publication date: 1996

DANMAC Status Report 1996

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Mikkelsen, H. (Ekstern), Thomsen, A. (Ekstern), Hansen, B. (Ekstern), Andersen, H. (Ekstern), Skriver, H. (. (ed.) (Ekstern), Groom, G. (Ekstern), Svendsen, M. (Ekstern), Broge, N. (Ekstern), Hasager, C. (Ekstern), Ji, J. (Ekstern), Jacobsen, A. (Ekstern), van der Keur, P. (Ekstern), Sandholt, I. (Ekstern), Nielsen, A. A. (Intern)
Publication date: 1996

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

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: 1996
Multivariate Statistical Analysis of Airborne Gamma Ray Detector Data

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Conradsen, K. (Intern)
Publication date: 1996

Pre-processing and Classification of EMISAR Data: PM019: DANMAC Data Report.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1996

Pre-processing and Classification of EMISAR Data: PM025: DANMAC Data Report

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1996

Pre-processing and Classification of GER 3715 Data: T2F1: DANMAC Data Report

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1996
Pre-processing and Classification of GER 3715 Data: T2F5: DANMAC Data Report.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1996

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Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research - peer-review › Report – Annual report year: 1996

Pre-processing and Classification of GER 3715 Data: T2F7: DANMAC Data Report.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Larsen, R. (Intern), Nielsen, A. A. (Intern), Conradsen, K. (Intern)
Publication date: 1996

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Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200954
Publication: Research - peer-review › Report – Annual report year: 1996

RoxAnn Measurements and Video based Mussel Mapping from Øresund, Denmark: Data Report.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern), Conradsen, K. (Intern)
Publication date: 1996

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Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200997
Publication: Research - peer-review › Report – Annual report year: 1996

Spatial Analysis of Multivariate, (Ir-)regularly Sampled Data: Geochemistry from the Eastern Erzgebirge: E.Y. Baafi and N.A. Schofield (Eds.)

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Ersbøll, B. K. (Intern), Palchen, W. (Ekstern), Rank, G. (Ekstern)
Publication date: 1996

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Statistisk behandling af målte fiberdiametre: Intern Rockwool Rapport

General information
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Organisations: Department of Informatics and Mathematical Modeling
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern)
Publication date: 1996

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165649
Publication: Research - peer-review › Report – Annual report year: 1996

Differentiation between geogenic and anthropogenic influences on soils in a mining processing area - some alternatives

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Palchen, W. (Ekstern), Rank, G. (Ekstern), Kluge, A. (Ekstern), Nielsen, A. A. (Intern), Ersbøll, B. K. (Intern)
Number of pages: 1
Publication date: 1995

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Title of host publication: Biometrics 95, 25-27 September 1995
Publisher: International Biometric Society Austrailasian Region
Main Research Area: Technical/natural sciences
Conference: Biometrics 95, 25-27 September 1995, 01/01/1995
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Source-ID: 200312
Publication: Research - peer-review › Article in proceedings – Annual report year: 1995

Analysis of Regularly and Irregularly Sampled Spatial, Multivariate, and Multi-temporal Data
This thesis describes different methods that are useful in the analysis of multivariate data. Some methods focus on spatial data (sampled regularly or irregularly), others focus on multitemporal data or data from multiple sources. The thesis covers selected and not all aspects of relevant data analysis techniques in this context. Geostatistics is described in Chapter 1. Tools as the semivariogram, the cross-semivariogram and different types of kriging are described. As an independent re-invention 2-D sample semivariograms, cross-semivariograms and cova functions, and modelling of 2-D sample semi-variograms are described. As a new way of setting up a well-balanced kriging support the Delaunay triangulation is suggested. Two case studies show the usefulness of 2-D semivariograms of geochemical data from areas in central Spain (with a geologist's comment) and South Greenland, and kriging/cokriging of an undersampled variable in South Greenland, respectively. Chapters 2 and 3 deal with various orthogonal transformations. Chapter 2 describes principal components (PC) analysis and two related spatial extensions, namely minimum/maximum autocorrelation factors (MAF) and minimum noise fractions (MNF) analysis. Whereas PCs maximize the variance represented by each component, MAFs maximize the spatial autocorrelation represented by each component, and MNFs maximize a measure of signal-to-noise ratio represented by each component. In the literature MAF/MNF analysis is described for regularly gridded data only. Here, the concepts are extended to irregularly sampled data via the Delaunay triangulation. As a link to the methods described in Chapter 1 a new type of kriging based on MAF/MNFs for irregularly spaced data is suggested. Also, a new way of removing periodic, salt-and-pepper and other types of noise based on Fourier filtering of MAF/MNFs is suggested. One case study successfully shows the effect of the MNF Fourier restoration. Another case shows the superiority of the MAF/MNF analysis over ordinary non-spatial factor analysis of geochemical data in South Greenland (with a geologist's comment). Also, two examples of MAF kriging are given. In Chapter 3 the two-set case is extended to multiset canonical correlations analysis (MUSECC). Two new applications to change detection studies are described: one is a new orthogonal transformation, multivariate alteration detection (MAD), based on two-set canonical correlations analysis; the other deals with transformations of minimum similarity canonical variates from a multiset analysis. The analysis of correlations between variables where observations are considered as repetitions is termed R-mode analysis. In Q-mode
analysis of correlations between observations, variables are considered as repetitions. Three case studies show the strength of the methods; one uses SPOT High Resolution Visible (HRV) multispectral (XS) data covering economically important pineapple and coffee plantations near Thika, Kiambu District, Kenya, the other two use Landsat Thematic Mapper (TM) data covering forested areas north of Umeå in northern Sweden. Here Q-mode performs better than R-mode analysis. The last case shows that because of the smart extension to univariate differences obtained by MAD analysis, all MAD components -also the high order MADs that contain information on maximum similarity as opposed to minimum similarity (i.e. change) contained in the low order MADs - are important in interpreting multivariate changes. This conclusion is supported by a (not shown) case study with simulated changes. Also the use of MAFs of MADs is successful. The absolute values of MADs and MAFs of MADs localize areas where big changes occur. Use of MAFs of high order multiset Q-mode canonical variates seems successful. Due to lack of ground truth data it is very hard to determine empirically which of the five multiset methods described is best (if any). Because of their strong ability to isolate noise both the MAD and the MUSECC techniques can be used iteratively to remove this noise.

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Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
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Electronic versions:
imm296.pdf
Source: orbit
Source-ID: 200834
Publication: Research › Ph.D. thesis – Annual report year: 1994

Progress Report on EC Funded Project BRE2-CT201

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Erbsøl, B. K. (Intern), Larsen, R. (Intern), Hartelius, K. (Intern), Carstensen, J. M. (Intern)
Publication date: 1994

Publication information
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200896
Publication: Research - peer-review › Report – Annual report year: 1994

Restoration of GERIS Data Using the Maximum Noise Fractions Transform
The Maximum Noise Fractions (MNF) transformation is used as a restoration tool in a 512x512 subscene of a 63 channel spectral dataset recorded over the Pyrite Belt in Southern Spain with the Geophysical Environmental Research Imaging Spectrometer (GERIS). The data obtained from such a scanning device are very useful in e.g. mineral exploration and environmental surveillance. Following the transformation from the original image space into the MNF space, a Fourier transformation of the MNFs (which are ordered by signal-to-noise ratio) will show more and more noise content. Also, the strong striping in primarily the visual bands of the scanner will be very conspicuous in the Fourier domain of only a few MNFs. We automatically detect the peaks in the Fourier spectra representing this striping, and if so desired we replace them by an iterated local mean value. Transforming back into the MNF space by the inverse Fourier transformation gives 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.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Larsen, R. (Intern)
Pages: 557-568
Publication date: 1994
Restoration of GERIS Data Using the Maximum Noise Fractions Transform,
Integration of multi-source data in mineral exploration

This paper describes several multivariate statistical analysis applications of geochemical, geophysical, and spectral variables in mineral exploration. Mahalanobis’ distance is described in some detail and based on four multisource variables this measure is applied to produce a map that gives an expression of the statistical proximity of each point in the map to a mineralized area. The four multisource variables chosen from a much larger set of variables have all been subject to extensive data processing: the geochemical variable is the noise MAF (minimum/maximum autocorrelation factor) of eleven kriging interpolated stream sediment variables; the geophysical variables are kriged aeromagnetic data iteratively moving average corrected to minimize the flight line striping and kriged Bouguer gravity anomaly data corrected for a quadratic trend; and the spectral variable is the density of automatically generated linear features based on Landsat TM data. The results indicate among other things a not previously recognized subsurface continuation of an already mapped lineament.
Noise removal in multichannel image data by a parametric maximum noise fraction estimator

Some approaches to noise removal in multispectral imagery are presented. The primary contribution of the present work is the establishment of several ways of estimating the noise covariance matrix from image data and a comparison of the noise separation performances. A case study with Landsat MSS data demonstrates that the principal components are not sorted correctly in terms of visual image quality, whereas the minimum/maximum autocorrelation factors and the maximum noise fractions (MAFs) are. A case study with Landsat TM data shows an ordering which is consistent with the spatial wavelength in the components. The case studies indicate that a better noise separation is attained when using more complex noise models than the simple model implied by MAF analysis. (L.M.)

A Geostatistical Approach to Indoor Surface Sampling Strategies

Particulate surface contamination is of concern in production industries such as food processing, aerospace, electronics and semiconductor manufacturing. There is also an increased awareness that surface contamination should be monitored in industrial hygiene surveys. A conceptual and theoretical framework for designing sampling strategies is thus developed. The distribution and spatial correlation of surface contamination can be characterized using concepts from geostatistical science, where spatial applications of statistics is most developed. The theory is summarized and particulate surface contamination, sampled from small areas on a table, have been used to illustrate the method. First, the spatial correlation is modelled and the parameters estimated from the data. Next, it is shown how the contamination at positions not measured can be estimated with kriging, a minimum mean square error method using the global information. Then methods for choosing a proper sampling area for a single sample of dust on a table are given. The global contamination of an object is determined by a maximum likelihood estimator. Finally, it is shown how specified experimental goals can be included to determine a suitable number of samples. The importance of including the spatial correlation into the calculations is demonstrated. Studies of the spatial correlation of particulate surface contamination will contribute to the understanding of particulate surface contamination processes.
Statistical methods and remote sensing techniques applied in analysis of combined geodata

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Conradsen, K. (Intern), Nielsen, A. A. (Intern), Ersbøll, B. K. (Intern), Pedersen, J. L. (Ekstern)
Pages: 245-272
A dynamic test method for the thermal performance of small houses

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern), Ersbøll, B. K. (Intern)
Number of pages: 31
Publication date: 1984

Host publication information
Title of host publication: ACEEE conference, Santa Cruz, California
Main Research Area: Technical/natural sciences
Conference: ACEEE conference, Santa Cruz, California, 01/01/1984
Source: orbit
Source-ID: 200272
Publication: Research - peer-review › Article in proceedings – Annual report year: 1984

Maisons consommant peu d'énergie: isolation et étanchéité à l'air/Low-Energy Houses: Insulation and Airtightness
The Hjortekar project of six low energy house designs north of Copenhagen has become renowned. Here, the authors, from the Thermal Insulation Laboratory, the Technical University of Denmark, explain some of the construction details to avoid cold bridges, including a new-type structural element, and to ensure airtightness. Test results of infiltration air change rates range from 0.02 to 0.12 a.c.h., while other tests show less than 15 per cent difference between calculated and measured transmission heat losses, which range from only 70 to 155 W/C. A discussion of the correlation of tests forms a major part of this article.

General information
State: Published
Organisations: Department of Buildings and Energy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Authors: Saxhof, B. (Intern), Nielsen, A. A. (Intern)
Pages: 142-153
Publication date: 1983
Main Research Area: Technical/natural sciences

Publication information
Journal: Bâtiment International/Building Research and Practice
Volume: 11
Issue number: 3
Original language: English
Links: http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=305
Source: orbit
Source-ID: 256830
Publication: Research - peer-review › Journal article – Annual report year: 1983

Om at holde hus med energien

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, A. A. (Intern)
Publication date: 1981

Host publication information
Projects:

Classification of Targets in Synthetic Aperture Radar Imaging

Technical University of Denmark
Period: 01/09/2014 → 13/12/2017
Number of participants: 7
Phd Student:
Malmgren-Hansen, David (Intern)
Supervisor:
Engholm, Rasmus (Ekstern)
Skriver, Henning (Intern)
Main Supervisor:
Nielsen, Allan Aasbjerg (Intern)
Examiner:
Winther, Ole (Intern)
Belongie, Serge (Ekstern)
Jenssen, Robert (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Convolutional Neural Networks - Generalizability and Interpretations
Project: PhD

Computerised Quantification of Motions Associated with Psychiatric Disorders

Technical University of Denmark
Period: 15/08/2014 → 28/02/2018
Number of participants: 8
Phd Student:
Einarsson, Gudmundur (Intern)
Supervisor:
Clemmensen, Line Katrine Harder (Intern)
Fink-Jensen, Anders (Ekstern)
Pagsberg, Anne Katrine (Ekstern)
Main Supervisor:
Paulsen, Rasmus Reinhold (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Gudmundsson, Steinn (Ekstern)
Moeslund, Thomas B. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Sparse Classification - Methods & Applications  
Project: PhD

Image Analysis for Nanoparticle Guided Radiotherapy  
Technical University of Denmark  
Period: 01/10/2012 → 21/01/2016  
Number of participants: 6  
Phd Student: Christensen, Anders Nymark (Intern)  
Supervisor: Larsen, Rasmus (Intern)  
Main Supervisor: Conradsen, Knut (Intern)  
Examiner: Nielsen, Allan Aasbjerg (Intern)  
Bech, Martin (Ekstern)  
Østergaard, Lasse Riis (Ekstern)

Financing sources  
Source: Internal funding (public)  
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet  
Project: PhD

Control and Surveillance of Automated Production Steps using Computer Vision  
Technical University of Denmark  
Period: 15/07/2012 → 25/08/2016  
Number of participants: 6  
Phd Student: Larsen, Anders Boesen Lindbo (Intern)  
Supervisor: Dahl, Anders Bjorholm (Intern)  
Main Supervisor: Larsen, Rasmus (Intern)  
Examiner: Nielsen, Allan Aasbjerg (Intern)  
Belongie, Serge (Ekstern)  
Nielsen, Mads (Ekstern)

Financing sources  
Source: Internal funding (public)  
Name of research programme: Eksternt finansieret virksomhed  
Project: PhD

Global and Artic Sea Level Change from Satellite Altimetry  
National Space Institute  
Period: 01/11/2011 → 18/09/2015  
Number of participants: 6  
Phd Student: Svendsen, Peter Limkilde (Intern)  
Supervisor: Nielsen, Allan Aasbjerg (Intern)  
Main Supervisor: Andersen, Ole Baltazar (Intern)  
Examiner: Høeg, Per (Intern)  
Kokkendorff, Simon Lyngby (Intern)  
Woodworth, Philip Leslie (Ekstern)
A Grand Challenge: Large Scale Event Recognition and Tracking

Technical University of Denmark
Period: 01/09/2011 → 21/11/2014
Number of participants: 6
Phd Student:
Vestergaard, Jacob Schack (Intern)
Supervisor:
Nielsen, Allan Aasbjerg (Intern)
Main Supervisor:
Larsen, Rasmus (Intern)
Examiner:
Carstensen, Jens Michael (Intern)
Benediktsson, Jón Ali (Ekstern)
Jenssen, Robert (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

SLS based dairy process control systems

Technical University of Denmark
Period: 15/12/2010 → 29/08/2014
Number of participants: 6
Phd Student:
Skytte, Jacob Lercke (Intern)
Supervisor:
Dahl, Anders Bjorholm (Intern)
Main Supervisor:
Larsen, Rasmus (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Parkkinen, Jussi (Ekstern)
Äström, Kalle (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

The Virtual Slaughterhouse - Constructing a virtual Knife

Department of Informatics and Mathematical Modeling
Period: 01/01/2006 → 01/07/2009
Number of participants: 6
Phd Student:
Hansen, Mads Fogtmann (Intern)
Supervisor:
Christensen, Lars Bager (Intern)
Main Supervisor:
Larsen, Rasmus (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Bajcsy, Ruzena (Ekstern)
Modersitzki, Jan (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

**CT Scanning and Automated Segmentation of Pig Bodies**
Department of Informatics and Mathematical Modeling
Period: 01/07/2005 → 11/02/2009
Number of participants: 6
Phd Student:
Vester-Christensen, Martin (Intern)
Supervisor:
Christensen, Lars Bager (Intern)
Main Supervisor:
Larsen, Rasmus (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Allen, Paul (Ekstern)
Barillot, Christian (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

**Detektering af falske ekkoer i data fra vejrradar**
Department of Informatics and Mathematical Modeling
Period: 01/10/2004 → 05/11/2008
Number of participants: 8
Phd Student:
Bøvh, Thomas (Ekstern)
Supervisor:
Gill, Rashpal S. (Ekstern)
Hansen, Lars Kai (Intern)
Overgaard, Søren (Ekstern)
Main Supervisor:
Nielsen, Allan Aasbjerg (Intern)
Examiner:
Larsen, Rasmus Werner (Intern)
Michelson, Daniel B. (Ekstern)
Rasmussen, Michael Robdrup (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

**Developement ofStatistical Methods and Models for Evaluation and Determination of Environmental monitoring programs**
Department of Informatics and Mathematical Modeling
Period: 01/04/2001 → 09/02/2005
Number of participants: 6
Phd Student:
Lophaven, Søren Nymand (Intern)
Supervisor:
Carstensen, Niels Jacob (Intern)
Main Supervisor:
Rootzén, Helle (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Grimvall, Anders (Ekstern)
Guttorp, Peter (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Fotogrammetrisk opbygning af 3D landskabs- og bymodeller
Department of Informatics and Mathematical Modeling
Period: 01/12/1999 → 28/10/2004
Number of participants: 7
Phd Student:
Olsen, Brian Pilemann (Intern)
Supervisor:
Frederiksen, Poul (Intern)
Knudsen, Per (Intern)
Main Supervisor:
Jacobi, Ole Illum (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)
Colomina, Ismael (Ekstern)
Höhle, Joachim (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskerakademiets Samfinansier
Project: PhD

Modelling of the geoid and the north Atlantic Sea level
Department of Informatics and Mathematical Modeling
Period: 01/10/1998 → 27/03/2002
Number of participants: 6
Phd Student:
Hilger, Klaus Baggesen (Intern)
Supervisor:
Nielsen, Allan Aasbjerg (Intern)
Main Supervisor:
Ersbøll, Bjarne Kjær (Intern)
Examiner:
Madsen, Henrik (Ekstern)
Switzer, Paul (Ekstern)
Windfeld, Kristian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsstipendium
Project: PhD
**2D og 3D objektmåling til styring og kvalitetskontrol i industrien**

Department of Systems Biology  
Period: 01/01/1997 → …  
Number of participants: 3  
Phd Student:  
Gramkow, Claus (Intern)  
Main Supervisor:  
Jessen, Flemming (Intern)  
Examiner:  
Nielsen, Allan Aasbjerg (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Erhvervsforskerordningen  
Project: PhD

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**The use of polarimetric SAR for the mapping and characterization of the natural environment**

Department of Informatics and Mathematical Modeling  
Period: 01/01/1997 → 19/07/2005  
Number of participants: 7  
Phd Student:  
Sørensen, Stéfán Meulengracht (Intern)  
Supervisor:  
Nielsen, Allan Aasbjerg (Intern)  
Skriver, Henning (Intern)  
Main Supervisor:  
Conradsen, Knut (Intern)  
Examiner:  
Carstensen, Jens Michael (Intern)  
Hasager, Charlotte Bay (Intern)  
Quegan, Shaun (Ekstern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Anden Forskningsrådsfinan.-SU  
Project: PhD

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**BioSonar (EU project MA53-CT95-0026)**

Monitoring of typical benthic communities and quantification of their living conditions is an important tool for establishing and maintaining knowledge about marine environments. The health of benthic communities is closely influenced by environmental impacts due to human activities in coastal areas, and many benthic communities have central roles in their ecosystems. In Northern Europe this applies to e.g. common mussels (Mytilus edulis) and in the Mediterranean to e.g. neptune grass (Posidonia oceanica). The neptune grass meadows and the common mussel beds play vital roles in favouring biological diversity in the marine ecosystems. Benthic communities are good environmental impact indicators as they respond in well-understood ways, and are important for the sustainability of their ecosystems. The priorities for protection of the environment are strengthened in these years, and the demands for information at higher resolution scales are continually rising. Thus, it is vital to develop methods and technology dedicated to deliver high resolution information on the health of the environment, in particular the difficult observable conditions at sea. The overall aim of the BIOSONAR project is to contribute to the development of technologies and methodologies for use of acoustic equipment in monitoring of biological communities at the sea floor. The project is considered a step towards a larger goal comprising development of equipment and data processing algorithms dedicated to produce sonar pictures of larger sea bottom areas on a level equivalent to current earth observation technology. The expected results of the project will be a validated methodology for estimation of distribution of benthic communities based on sonar monitoring.

Department of Informatics and Mathematical Modeling  
Period: 01/02/1996 → 31/01/1999  
Number of participants: 7  
Project participant:  
Sørensen, Per S. (Intern)  
Ersbøll, Bjarne Kjær (Intern)
DANMAC - DANish Multisensor Airborne Campaign
Project no.: 1243. The purpose of the project is to achieve a better understanding of the physical conditions and processes at the surface influencing the signal of both optical and radar sensors. The DANMAC project is a multisensor and multidisciplinary remote sensing campaign, consisting of four test sites covering one for agriculture/forestry, two for landscape-ecology/natural type and one for inland waters (lekes). For each test site extensive ground data collection takes place together with simultaneous data acquisition by airborne and spaceborne SAR's and/or optical/infrared sensors. Following the data collection, data processing, modelling and interpretation take place at the collaborating institutes in a coordinated effort.

Project

DECO, Danish Environmental monitoring of COastal waters. Project no.: 1221
Project no.: 1221. The traditional monitoring of the Danish marine environment is currently based primarily on ship sampling/measurements. All the various monitoring programmes ranging from the traditional environmental ones to fisheries monitoring and monitoring of spills from off-shore constructions can benefit from the utilization of remote sensing data. The satellites provide a temporal and spatial coverage, which is unmatched by other existing techniques. The current project will focus on environmental parameters (e.g. water quality parameters) influencing the optical, spectral signature of water (e.g. the reflectance of sun-light as a function of wavelength) in the visible to near-infrared part of the spectrum. These parameters are phytoplankton, suspended sediments and yellow substances. In shallow waters also bottom-types and depths influence the recorded signal. Three levels of simultaneous spectral measurements (in situ, airborne & spaceborne) will be included in order to make accurate correction for atmospheric and instrument specific distortions.

Project

GEOSONAR, GEOid and Sealevel Of the North Atlantic Region.
The goal of the GEOSONAR project is to develop methods for integrating multi sensor and multi channel satellite data for improved recovery of the sea level height. This will be carried out at regional scales (10-20 km) in the North Atlantic region as well as at local scales (3-5 km) in the Danish seas. Hereby, the understanding of the ocean, its state, and its dynamics will be improved. In turn, this will lead to enhanced ocean tides modelling, sea level forecasting and storm surge warning. Furthermore, Denmark will contribute to the success of EU COST action 40 that is currently being signed. An important goal is also to prepare for the dedicated gravity mission and develop methods for enhanced analysis of the gravity field, so that Denmark can play a central role in the future determination of the geoid, the sea level, and possible effects of Global Change.
**Bladskivebestemmelse for sukkerroer ved hjælp af billedanalyse**

**Administration**
Period: 01/05/1995 → …
Number of participants: 4
Phd Student:
Frydendal, Ib (Intern)
Supervisor:
Carstensen, Jens Michael (Intern)
Main Supervisor:
Conradsen, Knut (Intern)
Examiner:
Nielsen, Allan Aasbjerg (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

**Vegetation and soil**
Vegetation and soil parameters are important for studies using global circulation models. The parameters are essential in estimating and modelling e.g. surface energy balance, evapotranspiration, desertification, deforestation, and carbon dioxide circulation, and on a local scale on yield prediction and agricultural subsidiary enforcement. Vegetation and soil parameters such as soil moisture, vegetation type, structural characteristics for the vegetation (height, foliage, density), and vegetation biomass may be estimated from microwave remote sensing. The research aims at: 1) improving the techniques to determine vegetation type from SAR images, especially agricultural crops, but also with a view to natural vegetation, such as trees and heath; and 2) studying and evaluating algorithms for retrieval of vegetation and soil parameters, such as soil moisture, and vegetation height and biomass. The application of SAR to monitor agricultural crops, biomass and soil moisture is being studied in collaboration with Research Center Foulum (RCF). The farmland at RCF has been mapped each year from 1994 to 1998 from March to July with both L- and C-band polarimetric SAR. During the growing season and particularly at the time of data acquisition, a series of in-situ measurements was performed of soil and vegetation parameters. This information is used to interpret and model the backscatter characteristics of the soil and vegetation and forms the basis for studying methods for parameters retrieval. The main results of this project are new results in the understanding of scattering mechanisms for backscattering from agricultural crops, new methods for the classification of crops, and thorough evaluation of the classification potential of polarimetric SAR. Results have been or will be published at conferences and in papers.

Department of Electromagnetic Systems
Department of Informatics and Mathematical Modeling
Department of Electrical Engineering
Danish Institute of Agricultural Sciences
University of Copenhagen
National Environmental Research Institute
Period: 01/02/1994 → 31/12/2000
Number of participants: 7
Project participant:
Svendsen, Morten Thougaard (Intern)
McCloy, Keith (Ekstern)
Thomsen, Anton (Ekstern)
Hansen, Birger U. (Ekstern)
Nielsen, Allan Aasbjerg (Intern)
Segmentering og efterfølgende visualisering af 3-dimensionelle billeddata

Administration
Period: 01/04/1993 → 13/05/1997
Number of participants: 4
Phd Student: Bro-Nielsen, Morten (Intern)
Main Supervisor: Conradsen, Knut (Intern)
Examiner: Brady, Mike (Ekstern)
Nielsen, Allan Aasbjerg (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Statistiske metoder til genkendelse af mønstre og objektyper i billeder

Administration
Period: 01/04/1993 → 26/11/1997
Number of participants: 4
Phd Student: Rosholm, Anders (Intern)
Main Supervisor: Conradsen, Knut (Intern)
Examiner: Haslett, John (Ekstern)
Nielsen, Allan Aasbjerg (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Multivariate Data-analysis of regularly and irregularly sampled spatial data

Administration
Period: 01/01/1992 → 16/12/1994
Number of participants: 2
Phd Student: Nielsen, Allan Aasbjerg (Intern)
Main Supervisor: Conradsen, Knut (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: EF-finansieret
Activities:

**Multi-temporal images and semi-automatic map updating**
Period: 4 Mar 2010
Allan Aasbjerg Nielsen (Speaker)
National Space Institute
Geodesy

**Description**
Place: Ordnance Survey, Southampton, UK

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

**Kernel methods in change detection based on generalised multivariate difference images**
Period: 28 Jan 2010
Allan Aasbjerg Nielsen (Speaker)
National Space Institute
Geodesy

**Description**
Note: Invited contribution
Place: Center for Remote Sensing of Land Surfaces, University of Bonn, Germany

**Related external organisation**
Unknown external organisation
Activity: Talks and presentations › Conference presentations

**Least Squares Adjustment: Linear and Nonlinear Weighted Regression Analysis**
Period: 1 Jan 2007 → …
Allan Aasbjerg Nielsen (Other)
Geodesy
National Space Institute
Activity: Other