Phone-based metric as a predictor for basic personality traits

Basic personality traits are believed to be expressed in, and predictable from, smart phone data. We investigate the extent of this predictability using data (n = 636) from the Copenhagen Network Study, which to our knowledge is the most extensive study concerning smartphone usage and personality traits. Based on phone usage patterns, earlier studies have reported surprisingly high predictability of all Big Five personality traits. We predict personality trait tertiles (low, medium, high) from a set of behavioral variables extracted from the data, and find that only extraversion can be predicted significantly better (35.6%) than by a null model. Finally, we show that the higher predictabilities in the literature are likely due to overfitting on small datasets.

Academic performance and behavioral patterns

Identifying the factors that influence academic performance is an essential part of educational research. Previous studies have documented the importance of personality traits, class attendance, and social network structure. Because most of these analyses were based on a single behavioral aspect and/or small sample sizes, there is currently no quantification of the interplay of these factors. Here, we study the academic performance among a cohort of 538 undergraduate students forming a single, densely connected social network. Our work is based on data collected using smartphones, which the students used as their primary phones for two years. The availability of multi-channel data from a single population allows
us to directly compare the explanatory power of individual and social characteristics. We find that the most informative indicators of performance are based on social ties and that network indicators result in better model performance than individual characteristics (including both personality and class attendance). We confirm earlier findings that class attendance is the most important predictor among individual characteristics. Finally, our results suggest the presence of strong homophily and/or peer effects among university students.

**General information**
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Graz University of Technology
Authors: Kassarnig, V. (Ekstern), Mones, E. (Intern), Bjerre-Nielsen, A. (Ekstern), Sapiezynski, P. (Intern), Dreyer Lassen, D. (Ekstern), Lehmann, S. (Intern)
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**A Diagnostic and Predictive Framework for Wind Turbine Drive Train Monitoring**
Vast amount of data are collected minute by minute from wind turbines around the world. This thesis represents a focused research effort into discovering new ways of processing these data streams in order to gain insights which can be used to lower the maintenance costs of wind turbines and increase the turbine availability.

First, it is demonstrated how simple sensor data streams can be leveraged based on a combination of non-linear predictive models and unsupervised fault detection to provide warnings of a critical bearing failure more than a month earlier compared to existing alarm systems. Second, early fault identification based on analysis of complex vibration patterns which is a domain previously reserved for human experts, is shown to be solved with high accuracy using deep learning architecture strained in a fully supervised sense from the data collected in a large scale wind turbine monitoring platform. The research shows a way towards a fully automatized data-driven wind turbine diagnostic processing system that is highly scalable and requires little or no feature engineering and system modeling.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Bach-Andersen, M. (Intern), Winther, O. (Intern), Rømer-Odgaard, B. (Ekstern)
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Altered auditory processing and effective connectivity in 22q11.2 deletion syndrome

22q11.2 deletion syndrome (22q11.2DS) is one of the most common copy number variants and confers a markedly increased risk for schizophrenia. As such, 22q11.2DS is a homogeneous genetic liability model which enables studies to delineate functional abnormalities that may precede disease onset. Mismatch negativity (MMN), a brain marker of change detection, is reduced in people with schizophrenia compared to healthy controls. Using dynamic causal modelling (DCM), previous studies showed that top-down effective connectivity linking the frontal and temporal cortex is reduced in schizophrenia relative to healthy controls in MMN tasks. In the search for early risk-markers for schizophrenia we investigated the neural basis of change detection in a group with 22q11.2DS. We recorded high-density EEG from 19 young non-psychotic 22q11.2 deletion carriers, as well as from 27 healthy non-carriers with comparable age distribution and sex ratio, while they listened to a sequence of sounds arranged in a roving oddball paradigm. Despite finding no significant reduction in the MMN responses, whole-scalp spatiotemporal analysis of responses to the tones revealed a greater fronto-temporal N1 component in the 22q11.2 deletion carriers. DCM showed reduced intrinsic connection within right primary auditory cortex as well as in the top-down, connection from the right inferior frontal gyrus to right superior temporal gyrus for 22q11.2 deletion carriers although not surviving correction for multiple comparison. We discuss these findings in terms of reduced adaptation and a general increased sensitivity to tones in 22q11.2DS.
Automatic skull segmentation from MR images for realistic volume conductor models of the head: Assessment of the state-of-the-art

Anatomically realistic volume conductor models of the human head are important for accurate forward modeling of the electric field during transcranial brain stimulation (TBS), electro- (EEG) and magnetoencephalography (MEG). In particular, the skull compartment exerts a strong influence on the field distribution due to its low conductivity, suggesting the need to represent its geometry accurately. However, automatic skull reconstruction from structural magnetic resonance (MR) images is difficult, as compact bone has a very low signal in magnetic resonance imaging (MRI). Here, we evaluate three methods for skull segmentation, namely FSL BET2, the unified segmentation routine of SPM12 with extended spatial tissue priors, and the skullfinder tool of BrainSuite. To our knowledge, this study is the first to rigorously assess the accuracy of these state-of-the-art tools by comparison with CT-based skull segmentations on a group of ten subjects. We demonstrate several key factors that improve the segmentation quality, including the use of multi-contrast MRI data, the optimization of the MR sequences and the adaptation of the parameters of the segmentation methods. We conclude that FSL and SPM12 achieve better skull segmentations than BrainSuite. The former methods obtain reasonable results for the upper part of the skull when a combination of T1- and T2-weighted images is used as input. The SPM12-based results can be improved slightly further by means of simple morphological operations to fix local defects. In contrast to FSL BET2, the SPM12-based segmentation with extended spatial tissue priors and the BrainSuite-based segmentation provide coarse reconstructions of the vertebrae, enabling the construction of volume conductor models that include the neck. We exemplarily demonstrate that the extended models enable a more accurate estimation of the electric field distribution during transcranial direct current stimulation (tDCS) for montages that involve extraencephalic electrodes. The methods provided by FSL and SPM12 are integrated into pipelines for the automatic generation of realistic head models based on tetrahedral meshes, which are distributed as part of the open-source software package SimNIBS for field calculations for transcranial brain stimulation.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Electrical Engineering, Center for Magnetic Resonance, University of Copenhagen
Authors: Nielsen, J. D. (Intern), Madsen, K. H. (Intern), Puonti, O. (Intern), Siebner, H. R. (Ekstern), Bauer, C. (Ekstern), Madsen, C. G. (Ekstern), Saturnino, G. B. (Ekstern), Thielscher, A. (Intern)
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Scopus rating (2016): CiteScore 6.31 SJR 3.967 SNIP 1.759
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Scopus rating (2015): SJR 4.583 SNIP 1.852 CiteScore 6.71
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Scopus rating (2014): SJR 4.323 SNIP 2.03 CiteScore 6.9
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A Vibrotactile Alarm System for Pleasant Awakening
There has been a vast development of personal informatics devices combining sleep monitoring with alarm systems, in order to find an optimal time to awaken a sleeping person in a pleasant way. Most of these systems implement auditory feedback, which is not always pleasant and may disturb other sleepers. We present an adaptive alarm system that detects sleeping cycles and triggers alarm signal during shallow sleep, to minimize sleep inertia. Since tactile sensation is associated with positive valence, vibrotactile stimulation is investigated as a silent alarm to enhance pleasant awakening. Three modulation techniques to render the tactile stimuli for pleasant awakening are considered, namely simultaneous, continuous, and successive stimulation. Two experimental studies are conducted. Experiment 1 studied exogenous attention towards tactile stimulation in a multimodal scenario (involving visual and haptic interactions) with fully awake individuals. Results from the attention task and the subjective valence rating suggest that the vibrotactile stimulation should be based on the continuous modulation, since this not only is very perceivable but also associated with positive...
attention. Experiment 2 evaluated the user experience with tactile stimulation patterns during sleep. Results confirmed the findings of experiment 1. Continuous modulation was rated highest for pleasant yet arousing sleep-awake transition.

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Authors: Korres, G. (Ekstern), Jensen, C. B. F. (Intern), Park, W. (Ekstern), Bartsch, C. (Ekstern), Eid, M. (Ekstern)
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**Benefits of spatio-temporal modelling for short term wind power forecasting at both individual and aggregated levels**
The share of wind energy in total installed power capacity has grown rapidly in recent years. Producing accurate and reliable forecasts of wind power production, together with a quantification of the uncertainty, is essential to optimally integrate wind energy into power systems. We build spatio-temporal models for wind power generation and obtain full probabilistic forecasts from 15 minutes to 5 hours ahead. Detailed analysis of the forecast performances on the individual wind farms and aggregated wind power are provided. The predictions from our models are evaluated on a data set from wind farms in western Denmark using a sliding window approach, for which estimation is performed using only the last available measurements. The case study shows that it is important to have a spatio-temporal model instead of a temporal one to achieve calibrated aggregated forecasts. Furthermore, spatio-temporal models have the advantage of being able to produce spatially out-of-sample forecasts. We use a Bayesian hierarchical framework to obtain fast and accurate forecasts of wind power generation at wind farms where recent data are available, but also at a larger portfolio including wind farms without recent observations of power production. The results and the methodologies are relevant for wind power forecasts across the globe as well as for spatio-temporal modelling in general.

**General information**
State: Submitted
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy Analytics and Markets, Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Cognitive Systems, Norwegian University of Science and Technology
Authors: Lenzi, A. (Intern), Pinson, P. (Intern), Steinsland, I. (Ekstern)
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Scopus rating (2017): SNIP 0.875 SJR 1.014
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Scopus rating (2016): CiteScore 1.59 SJR 0.989 SNIP 1.029
Deep Generative Models for Molecular Science

Generative deep machine learning models now rival traditional quantum-mechanical computations in predicting properties of new structures, and they come with a significantly lower computational cost, opening new avenues in computational molecular science. In the last few years, a variety of deep generative models have been proposed for modeling molecules, which differ in both their model structure and choice of input features. We review these recent advances within deep generative models for predicting molecular properties, with particular focus on models based on the probabilistic autoencoder (or variational autoencoder, VAE) approach in which the molecular structure is embedded in a latent vector space from which its properties can be predicted and its structure can be restored.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Jørgensen, P. B. (Intern), Schmidt, M. N. (Intern), Winther, O. (Intern)
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Deep Generative Models for Semi-Supervised Machine Learning

The reintroduction of deep neural networks has a large impact on the modeling capabilities of modern machine learning. This reignites the general public's dream of achieving artificial intelligence, and spawns rapid progress in large scale industrial machine learning development, such as autonomous driving. However, the leaps in development are still confined to a rather limited learning domain, in which labeled data is required. Labeled data is hard and costly to acquire, due to the amount needed to efficiently learn a modern machine learning model, and that many data sources are not directly interpretable. Consequently, research in different learning paradigms that utilize vast amounts of unlabeled data is getting more and more attention. Albeit possessing intriguing theoretical properties, machine learning models that learn
from unlabeled data are still an unsolved research topic. The thesis comprises methods that utilize the power of deep neural networks to learn from both labeled and unlabeled data. A background for the theoretical foundation of the proposed methods are described and empirical results showing their capabilities within generation and classification tasks are presented. Finally, a real-life application within condition monitoring for sustainable energy is demonstrated, proving that the proposed methods have the expected impact and are applicable.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Maaløe, L. (Intern)
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Deep Latent Variable Models for Sequential Data
Over the last few decades an ever-increasing amount of data is being collected in a wide range of applications. This has boosted the development of mathematical models that are able to analyze it and discover its underlying structure, and use the extracted information to solve a multitude of different tasks, such as for predictive modelling or pattern recognition. The available data is however often complex and high-dimensional, making traditional data analysis methods ineffective in many applications. In the recent years there has then been a big focus on the development of more powerful models, that need to be general enough to be able to handle many diverse applications and kinds of data. Some of the most interesting advancements in this research direction have been recently obtained combining ideas from probabilistic modelling and deep learning. Variational auto-encoders (VAEs), that belong to the broader family of deep latent variable models, are powerful and scalable models that can be used for unsupervised learning of complex high-dimensional data distributions. They achieve this by parameterizing expressive probability distributions over the latent variables of the model using deep neural networks. VAEs can be used in applications with static data, for example as a generative model of images, but they are not suitable to model temporal data such as the sequences of images that form a video. However, a major part of the data that is being collected has a sequential nature, and finding powerful architectures that are able to model it is therefore fundamental. In the first part of the thesis we will introduce a broad class of deep latent variable models for sequential data, that can be used for unsupervised learning of complex and high-dimensional sequential data distributions. We obtain these models by extending VAEs to the temporal setting, and further combining ideas from deep learning (e.g. deep and recurrent neural networks) and probabilistic modelling (e.g. state-space models) to define generative models for the data that use deep neural networks to parameterize very flexible probability distributions. This results in a family of powerful architectures that can model a wide range of complex temporal data, and can be trained in a scalable way using large unlabelled datasets. In the second part of the thesis we will then present in detail three architectures belonging to this family of models. First, we will introduce stochastic recurrent neural networks (Fraccaro et al., 2016c), that combine the expressiveness of recurrent neural networks and the ability of state-space models to model the uncertainty in the learned latent representation. We will then present Kalman variational auto-encoders (Fraccaro et al., 2017), that can learn from data disentangled and more interpretable visual and dynamic representations. Finally, we will show that to deal with temporal applications that require a high memory capacity we can combine deep latent variable models with external memory architectures, as in the generative temporal model with spatial memory of Fraccaro et al. (2018).
Deep learning for automated drivetrain fault detection

A novel data-driven deep-learning system for large-scale wind turbine drivetrain monitoring applications is presented. It uses convolutional neural network processing on complex vibration signal inputs. The system is demonstrated to learn successfully from the actions of human diagnostic experts and provide early and robust fault detection on both rotor bearing, planetary and helical stage gear box bearings from analysis of multisensor vibration patterns using only a high-level feature selection. On the basis of data from 251 actual wind turbine bearing failures, we are able to accurately quantify the fleet-wide diagnostic model performance. The analysis also explores the time dependence of the diagnostic performance, providing a detailed view of the timeliness and accuracy of the diagnostic outputs across the different architectures. Deep architectures are shown to outperform the human analyst as well as shallow-learning architectures, and the results demonstrate that when applied in a large-scale monitoring system, machine intelligence is now able to handle some of the most challenging diagnostic tasks related to wind turbines.
Design process robustness: A bi-partite network analysis reveals the central importance of people

Design processes require the joint effort of many people to collaborate and work on multiple activities. Effective techniques to analyse and model design processes are important for understanding organisational dynamics, for improving collaboration, and for planning robust design processes, reducing the risk of rework and delays. Although there has been much progress in modelling and understanding design processes, little is known about the interplay between people and the activities they perform and its influence on design process robustness. To analyse this interplay, we model a large-scale design process of a biomass power plant with people and activities as a bipartite network. Observing that some people act as bridges between activities organised to form nearly independent modules, in order to evaluate process fragility, we simulate random failures and targeted attacks to people and activities. We find that our process is more vulnerable to attacks to people rather than activities. These findings show how the allocation of people to activities can obscure an inherent fragility, making the process highly sensitive and dependent on specific people. More generally, we show that the behaviour of robustness is determined by the degree distributions, the heterogeneity of which can be leveraged to improve robustness and resilience to cascading failures. Overall, we show that it is important to carefully plan the assignment of people to activities.

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Organisations: Department of Management Engineering, Engineering Systems, Copenhagen Center for Health Technology, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Piccolo, S. (Intern), Jørgensen, S. L. (Intern), Maier, A. (Intern)
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FindZebra - using machine learning to aid diagnosis of rare diseases

FindZebra is a search engine for rare diseases intended to act as a diagnosis decision support system (DDSS) capable of assisting the user both during and after a search. Rare diseases are diseases that affect only a small part of the population (less than one in two thousand). Currently around seven thousand rare diseases are known and it is estimated that 0–6% of the population will be affected by a rare disease during their lifetime. Due to their rarity and large number, diagnosis of rare diseases is difficult and often associated with year long delays and diagnostic errors. These difficulties with diagnosis have a profound human and societal cost. This means that even a small increase in success rate when using a tool such as FindZebra could potentially have a great impact on society. In this dissertation we explore four lines of research for improving FindZebra using machine learning methods. The first line of research is on how to improve the retrieval performance of FindZebra. By using a combination of improved models, medical databases and corpus expansion we show that it is possible to obtain a substantial improvement in retrieval performance compared to current state-of-the-art document retrieval systems. Improving retrieval performance is important, but is not the only way of improving the success rate of a DDSS such as FindZebra. Following an unsuccessful search, the search engine should assist the user by indicating what information is likely to be missing. This idea is called Information Completion (IC) and will be explored in the second line of research. In order to represent words (and other discrete tokens) in a neural network it is necessary to transform each word to a vector form. This is typically accomplished by using a word embedding, which is an essential component in any word based neural network. The third line of research is on how to improve this basic component. Users of FindZebra who do not have English as their primary language often have difficulty expressing complex medical queries in English. Optimally, a user should be able to write a query in his or her native language and the search engine should then give a suggestion for a differential diagnosis based on all the information contained in a multilingual corpus, not only in the native corpus. Methods for performing multilingual search will be the fourth line of research explored in this dissertation.

General information

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Authors: Svenstrup, D. T. (Intern)
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Frontal Brain Asymmetry and Willingness to Pay

Consumers frequently make decisions about how much they are willing to pay (WTP) for specific products and services, but little is known about the neural mechanisms underlying such calculations. In this study, we were interested in testing whether specific brain activation—the asymmetry in engagement of the prefrontal cortex—would be related to consumer
choice. Subjects saw products and subsequently decided how much they were willing to pay for each product, while undergoing neuroimaging using electroencephalography. Our results demonstrate that prefrontal asymmetry in the gamma frequency band, and a trend in the beta frequency band that was recorded during product viewing was significantly related to subsequent WTP responses. Frontal asymmetry in the alpha band was not related to WTP decisions. Besides suggesting separate neuropsychological mechanisms of consumer choice, we find that one specific measure—the prefrontal gamma symmetry—was most strongly related to WTP responses, and was most coupled to the actual decision phase. These findings are discussed in light of the psychology of WTP calculations, and in relation to the recent emergence of consumer neuroscience and neuromarketing.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Singularity University, Neurons Inc., Copenhagen Business School
Authors: Ramsøy, T. Z. (Ekstern), Skov, M. (Ekstern), Christensen, M. K. (Ekstern), Stahlhut, C. (Intern)
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Scopus rating (2016): CiteScore 3.85 SJR 1.941 SNIP 1.092
Scopus rating (2015): SJR 2.041 SNIP 1.088 CiteScore 3.72
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Scopus rating (2013): SJR 2.096 SNIP 1.101 CiteScore 3.61
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Functional Connectivity using a Wishart Mixture Model

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Nielsen, S. F. V. (Intern), Madsen, K. H. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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A patient with motor conversion disorder presented with a functional paresis of the left hand. After exclusion of structural brain damage, she was repeatedly examined with whole-brain functional magnetic resonance imaging, while she performed visually paced finger-tapping tasks. The dorsal premotor cortex showed a bilateral deactivation in the acute-subacute phase. Recovery from unilateral hand paresis was associated with a gradual increase in task-based activation of the dorsal premotor cortex bilaterally. The right medial prefrontal cortex displayed the opposite pattern, showing initial task-based activation that gradually diminished with recovery. The inverse dynamics of premotor and medial prefrontal activity over time were found during unimanual finger-tapping with the affected and non-affected hand as well as during bimanual finger-tapping. These observations suggest that reduced premotor and increased medial prefrontal activity reflect an effector-independent cortical dysfunction in conversion paresis which gradually disappears in parallel with clinical remission of paresis. The results link the medial prefrontal and dorsal premotor areas to the generation of intentional actions. We hypothesise that an excessive ‘veto’ signal generated in medial prefrontal cortex along with decreased premotor activity might constitute the functional substrate of conversion disorder. This notion warrants further examination in a larger group of affected patients.

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- **State:** Accepted/In press
- **Organisations:** Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
- **Authors:** Dogonowski, A. M. (Ekstern), Andersen, K. W. (Ekstern), Sellebjerg, F. (Ekstern), Schreiber, K. (Ekstern), Madsen, K. H. (Intern), Siebner, H. R. (Ekstern)
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    - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 2
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    - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
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  - Scopus rating (2013): SJR 4.489 SNIP 2.028 CiteScore 7.06
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  - Scopus rating (2012): SJR 4.026 SNIP 1.972 CiteScore 6.86
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    - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 2
  - Scopus rating (2011): SJR 3.728 SNIP 1.818 CiteScore 6.31
    - ISI indexed (2011): ISI indexed yes
    - Web of Science (2011): Indexed yes
  - BFI (2010): BFI-level 2
In this paper we propose a combination of Mathematical Optimization and Machine Learning to estimate the value of optimized solutions. In particular, we investigate if a machine, trained on a large number of optimized solutions, could accurately estimate the value of the optimized solution for new instances. In this paper we will focus on a specific application: the offshore wind farm layout optimization problem. Mixed Integer Programming models and other state-of-the-art optimization techniques, have been developed to solve this problem. Given the complexity of the problem and the big difference in production between optimized/non optimized solutions, it is not trivial to understand the potential value of a new site without running a complete optimization. This could be too time consuming if a lot of sites need to be evaluated, therefore we propose to use Machine Learning to quickly estimate the potential of new sites (i.e., to estimate the optimized production of a site without explicitly running the optimization). To do so, we trained and tested different Machine Learning models on a dataset of 3000+ optimized layouts found by the optimizer. Thanks to the close collaboration with a leading company in the energy sector, our model was trained on real-world data. Our results show that Machine Learning is able to efficiently estimate the value of optimized instances for the offshore wind farm layout problem.
Optimizing targeted vaccination across cyber-physical networks: an empirically based mathematical simulation study

Targeted vaccination, whether to minimize the forward transmission of infectious diseases or their clinical impact, is one of the 'holy grails' of modern infectious disease outbreak response, yet it is difficult to achieve in practice due to the challenge of identifying optimal targets in real-time. If interruption of disease transmission is the goal, targeting requires knowledge of underlying person-to-person contact networks. Digital communication networks may reflect not only virtual but also physical interactions that could result in disease transmission, but the precise overlap between these cyber and physical networks has never been empirically explored in real-life settings. Here, we study the digital communication activity of more than 500 individuals along with their person-to-person contacts at a 5-min temporal resolution. We then simulate different disease transmission scenarios on the person-to-person physical contact network to determine whether cyber communication networks can be harnessed to advance the goal of targeted vaccination for a disease spreading on the network of physical proximity. We show that individuals selected on the basis of their closeness centrality within cyber networks (what we call 'cyber-directed vaccination') can enhance vaccination campaigns against diseases with short-range (but not full-range) modes of transmission.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Massachusetts Institute of Technology, Cornell University
Authors: Mones, E. (Intern), Stopczynski, A. (Intern), Pentland, A. ’. (Ekstern), Hupert, N. (Ekstern), Lehmann, S. (Intern)
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BFI (2012): BFI-level 1
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Web of Science (2012): Indexed yes
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Scopus rating (2011): CiteScore 4.53
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BFI (2009): BFI-level 1
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Perspectives on Machine Learning for Classification of Schizotypy Using fMRI Data

Functional magnetic resonance imaging is capable of estimating functional activation and connectivity in the human brain, and lately there has been increased interest in the use of these functional modalities combined with machine learning for identification of psychiatric traits. While these methods bear great potential for early diagnosis and better understanding of disease processes, there are wide ranges of processing choices and pitfalls that may severely hamper interpretation and generalization performance unless carefully considered. In this perspective article, we aim to motivate the use of machine learning schizotypy research. To this end, we describe common data processing steps while commenting on best practices and procedures. First, we introduce the important role of schizotypy to motivate the importance of reliable classification, and summarize existing machine learning literature on schizotypy. Then, we describe procedures for extraction of features based on fMRI data, including statistical parametric mapping, parcellation, complex network analysis, and decomposition methods, as well as classification with a special focus on support vector classification and deep learning. We provide more detailed descriptions and software as supplementary material. Finally, we present current challenges in machine learning for classification of schizotypy and comment on future trends and perspectives.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital, Chinese Academy of Sciences
Authors: Madsen, K. H. (Intern), Krohne, L. G. (Ekstern), Cai, X. (Ekstern), Wang, Y. (Ekstern), Chan, R. C. K. (Ekstern)
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BFI (2014): BFI-level 2
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ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 4.801 SNIP 2.795 CiteScore 7.39
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Scopus rating (2011): SJR 4.674 SNIP 2.846 CiteScore 7.62
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 4.22 SNIP 2.404
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 3.691 SNIP 2.185
Web of Science (2009): Indexed yes
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Predictive assessment of models for dynamic functional connectivity

In neuroimaging, it has become evident that models of dynamic functional connectivity (dFC), which characterize how intrinsic brain organization changes over time, can provide a more detailed representation of brain function than traditional static analyses. Many dFC models in the literature represent functional brain networks as a meta-stable process with a discrete number of states; however, there is a lack of consensus on how to perform model selection and learn the number of states, as well as a lack of understanding of how different modeling assumptions influence the estimated state dynamics. To address these issues, we consider a predictive likelihood approach to model assessment, where models are evaluated based on their predictive performance on held-out test data. Examining several prominent models of dFC (in their probabilistic formulations) we demonstrate our framework on synthetic data, and apply it on two real-world examples: a face recognition EEG experiment and resting-state fMRI. Our results evidence that both EEG and fMRI are better characterized using dynamic modeling approaches than by their static counterparts, but we also demonstrate that one must be cautious when interpreting dFC because parameter settings and modeling assumptions, such as window lengths and emission models, can have a large impact on the estimated states and consequently on the interpretation of the brain dynamics.
Slice-wise motion tracking during simultaneous EEG-fMRI

Slice-wise motion tracking during combined electroencephalography (EEG) and echo planar imaging (EPI) is developed. Using gradient-induced noise on the EEG for tracking, no interleaved navigator modules or additional hardware is needed. The motion parameters are determined after a calibration and training scan. The method is explored in a phantom and in vivo.

General information
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Organisations: Department of Electrical Engineering, Center for Magnetic Resonance, Department of Applied Mathematics and Computer Science, Cognitive Systems, Center for Hyperpolarization in Magnetic Resonance, Philips - Copenhagen, Copenhagen University Hospital, Chinese Academy of Sciences
Spatio-temporal methods for EEG analysis in cognitive neuroscience

Electroencephalography (EEG) records electrical activity from the brain by measuring the resulting potential differences across the scalp. It has a long tradition in both a clinical and neuroscientific setting, and recently it has also started being used for consumer-oriented applications. While EEG can be a useful tool, it can be difficult to decipher information from its raw signals. In this thesis I will present three projects with the common goal of analysing EEG in ways that both extract meaningful information and visualise it in intuitive ways. The first project describes how we took neuroscience out of the laboratory and into the classroom. We reproduced an attention-tracking paradigm in a classroom and simultaneously recorded the neural activity of up to nine people. We had a focus on using equipment that was wireless and portable as well being relatively low-cost and computational methods in a setup that is feasible to extend into everyday scenarios. The second project revolved around creating a toolbox for the research field of microstate analysis, with a focus on open access and transparency of the applied methods. The toolbox is followed by a methodological guide that reviews the most commonly applied algorithms in microstate analysis. In the final project I investigated the feasibility of using the complexity of EEG as a neural marker of conscious processing. This project spans two studies investigating the capability of EEG complexity in two different scenarios; while people are sleeping, and while navigating a helicopter simulator.

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Authors: Poulsen, A. T. (Intern)
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Task-Modulated Cortical Representations of Natural Sound Source Categories

In everyday sound environments, we recognize sound sources and events by attending to relevant aspects of an acoustic input. Evidence about the cortical mechanisms involved in extracting relevant category information from natural sounds is, however, limited to speech. Here, we used functional MRI to measure cortical response patterns while human listeners categorized real-world sounds created by objects of different solid materials (glass, metal, wood) manipulated by different sound-producing actions (striking, rattling, dropping). In different sessions, subjects had to identify either material or action categories in the same sound stimuli. The sound-producing action and the material of the sound source could be decoded from multivoxel activity patterns in auditory cortex, including Heschl’s gyrus and planum temporale. Importantly, decoding success depended on task relevance and category discriminability. Action categories were more accurately decoded in auditory cortex when subjects identified action information. Conversely, the material of the same sound sources was decoded with higher accuracy in the inferior frontal cortex during material identification. Representational similarity analyses indicated that both early and higher-order auditory cortex selectively enhanced spectrotemporal features relevant to the target category. Together, the results indicate a cortical selection mechanism that favors task-relevant information in the processing of nonvocal sound categories.

General information
Understanding predictability and exploration in human mobility

Predictive models for human mobility have important applications in many fields including traffic control, ubiquitous computing, and contextual advertisement. The predictive performance of models in literature varies quite broadly, from over 90% to under 40%. In this work we study which underlying factors - in terms of modeling approaches and spatio-temporal characteristics of the data sources - have resulted in this remarkably broad span of performance reported in the literature. Specifically we investigate which factors influence the accuracy of next-place prediction, using a high-precision location dataset of more than 400 users observed for periods between 3 months and one year. We show that it is much easier to achieve high accuracy when predicting the time-bin location than when predicting the next place. Moreover, we demonstrate how the temporal and spatial resolution of the data have strong influence on the accuracy of prediction. Finally we reveal that the exploration of new locations is an important factor in human mobility, and we measure that on average 20-25% of transitions are to new places, and approx. 70% of locations are visited only once. We discuss how these mechanisms are important factors limiting our ability to predict human mobility.

How to target inter-regional phase synchronization with dual-site Transcranial Alternating Current Stimulation

Large-scale synchronization of neural oscillations is a key mechanism for functional information exchange among brain areas. Dual-site Transcranial Alternating Current Stimulation (ds-TACS) has been recently introduced as non-invasive technique to manipulate the temporal phase relationship of local oscillations in two connected cortical areas. While the frequency of ds-TACS is matched, the phase of stimulation is either identical (in-phase stimulation) or opposite (anti-phase
stimulation) in the two cortical target areas. In-phase stimulation is thought to synchronize the endogenous oscillations and hereby to improve behavioral performance. Conversely, anti-phase stimulation is thought to desynchronize neural oscillations in the two areas, which is expected to decrease performance. Critically, in- and anti-phase ds-TACS should only differ with respect to temporal phase, while all other stimulation parameters such as focality and stimulation intensity should be matched to enable an unambiguous interpretation of the behavioral effects. Using electric field simulations based on a realistic head geometry, we tested how well this goal has been met in studies, which have employed ds-TACS up to now. Separating the induced electrical fields in their spatial and temporal components, we investigated how the chosen electrode montages determined the spatial field distribution and the generation of phase variations in the injected electric fields. Considering the basic physical mechanisms, we derived recommendations for an optimized stimulation montage. The latter allows for a principled design of in- and anti-phase ds-TACS conditions with matched spatial distributions of the electric field. This knowledge will help cognitive neuroscientists to design optimal ds-TACS configurations, which are suited to probe unambiguously the causal contribution of phase coupling to specific cognitive processes in the human brain.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Center for Magnetic Resonance, Department of Electrical Engineering, University of Copenhagen, Danish Research Centre for Magnetic Resonance
Authors: Saturnino, G. B. (Ekstern), Madsen, K. H. (Intern), Siebner, H. R. (Ekstern), Thielscher, A. (Intern)
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Scopus rating (2015): SJR 4.583 SNIP 1.852 CiteScore 6.71
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BFI (2014): BFI-level 2
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2011): SJR 3.728 SNIP 1.818 CiteScore 6.31
ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 3.654 SNIP 1.869
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New frontiers of quantified self 3: Exploring understudied categories of users

Quantified Self (QS) field needs to start thinking of how situated needs may affect the use of self-tracking technologies. In this workshop we will focus on the idiosyncrasies of specific categories of users.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Turin, University of Sydney, University of Glasgow, Technische Universität Berlin, University of Washington, Madeira Interactive Technologies Institute
Authors: Rapp, A. (Ekstern), Cena, F. (Ekstern), Kay, J. (Ekstern), Kummerfeld, B. (Ekstern), Hopfgartner, F. (Ekstern), Plumbaum, T. (Ekstern), Larsen, J. E. (Intern), Epstein, D. A. (Ekstern), Gouveia, R. (Ekstern)
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Flexible non-linear predictive models for large-scale wind turbine diagnostics
We demonstrate how flexible non-linear models can provide accurate and robust predictions on turbine component temperature sensor data using data-driven principles and only a minimum of system modeling. The merits of different model architectures are evaluated using data from a large set of turbines operating under diverse conditions. We then go on to test the predictive models in a diagnostic setting, where the output of the models are used to detect mechanical faults in rotor bearings. Using retrospective data from 22 actual rotor bearing failures, the fault detection performance of the models are quantified using a structured framework that provides the metrics required for evaluating the performance in a fleet wide monitoring setup. It is demonstrated that faults are identified with high accuracy up to 45 days before a warning from the hard-threshold warning system.
22q11.2 Deletion Syndrome Is Associated With Impaired Auditory Steady-State Gamma Response

The 22q11.2 deletion syndrome confers a markedly increased risk for schizophrenia. 22q11.2 deletion carriers without manifest psychotic disorder offer the possibility to identify functional abnormalities that precede clinical onset. Since schizophrenia is associated with a reduced cortical gamma response to auditory stimulation at 40 Hz, we hypothesized that the 40 Hz auditory steady-state response (ASSR) may be attenuated in nonpsychotic individuals with a 22q11.2 deletion. Eighteen young nonpsychotic 22q11.2 deletion carriers and a control group of 27 noncarriers with comparable age range (12-25 years) and sex ratio underwent 128-channel EEG. We recorded the cortical ASSR to a 40 Hz train of clicks, given either at a regular inter-stimulus interval of 25 ms or at irregular intervals jittered between 11 and 37 ms. Healthy noncarriers expressed a stable ASSR to regular but not in the irregular 40 Hz click stimulation. Both gamma power and inter-trial phase coherence of the ASSR were markedly reduced in the 22q11.2 deletion group. The ability to phase lock cortical gamma activity to regular auditory 40 Hz stimulation correlated with the individual expression of negative symptoms in deletion carriers (ρ = -0.487, P = .041). Nonpsychotic 22q11.2 deletion carriers lack efficient phase locking of evoked gamma activity to regular 40 Hz auditory stimulation. This abnormality indicates a dysfunction of fast intracortical oscillatory processing in the gamma-band. Since ASSR was attenuated in nonpsychotic deletion carriers, ASSR deficiency may constitute a premorbid risk marker of schizophrenia.

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Web of Science (2017): Indexed Yes
Active Self-Tracking of Subjective Experience with a One-Button Wearable: A Case Study in Military PTSD

We describe a case study with the participation of a Danish veteran suffering from post-traumatic stress disorder (PTSD). As part of psychotherapeutic treatment the participant and therapist have used our novel technique for instrumenting self-tracking of select aspects of subjective experience using a one-button wearable device. The instrumentation system is described along with the specific self-tracking protocol which defined the participant’s self-tracking of a single symptom, namely the occurrences of a bodily experienced precursor to hyperarousal. Results from the case study demonstrate how self-tracking data on a single symptom collected by a patient can provide valuable input to the therapeutic process. Specifically, it facilitated identification of crucial details otherwise unavailable from the clinical assessment and even became decisive in disentangling different symptoms and their causes.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Danish Defence Research Establishment
Authors: Larsen, J. E. (Intern), Eskelund, K. (Ekstern), Christiansen, T. B. (Ekstern)
Active vibration-based structural health monitoring system for wind turbine blade: Demonstration on an operating Vestas V27 wind turbine

This study presents a structural health monitoring system that is able to detect structural defects of wind turbine blade such as cracks, leading/trailing-edge opening, or delamination. It is shown that even small defects of at least 15 cm size can be detected remotely without stopping the wind turbine. The structural health monitoring system presented is vibration-based: mechanical energy is artificially introduced by means of an electromechanical actuator, whose plunger periodically hits the blade. The induced vibrations propagate along the blade and are picked up by accelerometers mounted along the blade. The vibrations in mid-range frequencies are utilized: this range is above the frequencies excited by blade–wind interaction, ensuring a good signal-to-noise ratio. At the same time, the corresponding wavelength is short enough to deliver required damage detection resolution and long enough to be able to propagate the entire blade length. This article demonstrates the system on a Vestas V27 wind turbine. One blade of the wind turbine was equipped with the system, and a 3.5-month monitoring campaign was conducted while the turbine was operating normally. During the campaign, a defect—a trailing-edge opening—was artificially introduced into the blade and its size was gradually increased from the original 15 to 45 cm. Using a semi-supervised learning algorithm, the system was able to detect even the smallest amount of damage while the wind turbine was operating under different weather conditions. This article provides detailed information about the instrumentation and the measurement campaign and explains the damage detection algorithm.
Adaptive Smoothing in fMRI Data Processing Neural Networks

Functional Magnetic Resonance Imaging (fMRI) relies on multi-step data processing pipelines to accurately determine brain activity; among them, the crucial step of spatial smoothing. These pipelines are commonly suboptimal, given the local optimisation strategy they use, treating each step in isolation. With the advent of new tools for deep learning, recent work has proposed to turn these pipelines into end-to-end learning networks. This change of paradigm offers new avenues to improvement as it allows for a global optimisation. The current work aims at benefiting from this paradigm shift by defining a smoothing step as a layer in these networks able to adaptively modulate the degree of smoothing required by each brain volume to better accomplish a given data analysis task. The viability is evaluated on real fMRI data where subjects did alternate between left and right finger tapping tasks.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Center for Health Technology, Danish Research Centre for Magnetic Resonance
Authors: Vilamala, A. (Intern), Madsen, K. H. (Ekstern), Hansen, L. K. (Intern)
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A deep learning approach to adherence detection for type 2 diabetics
Diabetes has become one of the biggest health problems in the world. In this context, adherence to insulin treatment is essential in order to avoid life-threatening complications. In this pilot study, a novel adherence detection algorithm using Deep Learning (DL) approaches was developed for type 2 diabetes (T2D) patients, based on simulated Continuous Glucose Monitoring (CGM) signals. A large and diverse amount of CGM signals were simulated for T2D patients using a T2D adapted version of the Medtronic Virtual Patient (MVP) model for T1D. By using these signals, different classification algorithms were compared using a comprehensive grid search. We contrast a standard logistic regression baseline to
Multi-Layer Perceptrons (MLPs) and Convolutional Neural Networks (CNNs). The best classification performance with an average accuracy of 77.5% was achieved with CNN. Hence, this indicates the potential of DL, when considering adherence detection systems for T2D patients.

**General information**
State: Published
Authors: Mohebbi, A. (Ekstern), Aradóttir, T. B. (Intern), Johansen, A. R. (Intern), Bengtsson, H. (Ekstern), Fraccaro, M. (Intern), Mørup, M. (Intern)
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**A Disentangled Recognition and Nonlinear Dynamics Model for Unsupervised Learning**
This paper takes a step towards temporal reasoning in a dynamically changing video, not in the pixel space that constitutes its frames, but in a latent space that describes the non-linear dynamics of the objects in its world. We introduce the Kalman variational auto-encoder, a framework for unsupervised learning of sequential data that disentangles two latent representations: an object’s representation, coming from a recognition model, and a latent state describing its dynamics. As a result, the evolution of the world can be imagined and missing data imputed, both without the need to generate high dimensional frames at each time step. The model is trained end-to-end on videos of a variety of simulated physical systems, and outperforms competing methods in generative and missing data imputation tasks.

**General information**
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Google Deepmind
Authors: Fraccaro, M. (Intern), Kamronn, S. D. (Intern), Paquet, U. (Ekstern), Winther, O. (Intern)
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**Alterations in the brain's connectome during recovery from severe traumatic brain injury: Protocol for a longitudinal prospective study**
Introduction Traumatic brain injury (TBI) is considered one of the most pervasive causes of disability in people under the age of 45. TBI often results in disorders of consciousness, and clinical assessment of the state of consciousness in these patients is challenging due to the lack of behavioural responsiveness. Functional neuroimaging offers a means to assess these patients without the need for behavioural signs, indicating that brain connectivity plays a major role in consciousness emergence and maintenance. However, little is known regarding how changes in connectivity during recovery from TBI accompany changes in the level of consciousness. Here, we aim to combine cutting-edge neuroimaging techniques to follow changes in brain connectivity in patients recovering from severe TBI. Methods and analysis A multimodal longitudinal assessment of 30 patients in the subacute stage after severe TBI will be made comprising an MRI session
combined with electroencephalography (EEG), a positron emission tomography session and a transcranial magnetic stimulation (TMS) combined with EEG (TMS/EEG) session. A group of 20 healthy participants will be included for comparison. Four sessions for patients and two sessions for healthy participants will be planned. Data analysis techniques will focus on whole-brain, both data-driven and hypothesis-driven, connectivity measures that will be specific to the imaging modality. Ethics and dissemination The project has received ethical approval by the local ethics committee of the Capital Region of Denmark and by the Danish Data Protection. Results will be published as original research articles in peer-reviewed journals and disseminated in international conferences. None of the measurements will have any direct clinical impact on the patients included in the study but may benefit future patients through a better understanding of the mechanisms underlying the recovery process after TBI. Trial registration number: NCT02424656; Pre-results.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Conde, V. (Ekstern), Andreasen, S. H. (Ekstern), Petersen, T. H. (Ekstern), Larsen, K. B. (Ekstern), Madsen, K. (Ekstern), Andersen, K. W. (Ekstern), Akopian, I. (Ekstern), Madsen, K. H. (Intern), Hansen, C. P. (Ekstern), Poulsen, I. (Ekstern), Kammersgaard, L. P. (Ekstern), Siebner, H. R. (Ekstern)
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An introduction to Deep learning on biological sequence data - Examples and solutions
Deep neural network architectures such as convolutional and long short-term memory networks have become increasingly popular as machine learning tools during the recent years. The availability of greater computational resources, more data, new algorithms for training deep models and easy to use libraries for implementation and training of neural networks are the drivers of this development. The use of deep learning has been especially successful in image recognition; and the development of tools, applications and code examples are in most cases centered within this field rather than within biology. Here, we aim to further the development of deep learning methods within biology by providing application examples and ready to apply and adapt code templates. Given such examples, we illustrate how architectures consisting of convolutional and long short-term memory neural networks can relatively easily be designed and trained to state-of-the-art performance on three biological sequence problems: prediction of subcellular localization, protein secondary structure and the binding of peptides to MHC Class II molecules. All implementations and datasets are available online to the scientific community at https://github.com/vanessajurtz/lasagne4bio. Supplementary data are available at Bioinformatics online.

General information
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Organisations: Department of Bio and Health Informatics, Immunoinformatics and Machine Learning, Department of Applied Mathematics and Computer Science, Department of Electrical Engineering, Disease Intelligence and Molecular
A pseudo-Voigt component model for high-resolution recovery of constituent spectra in Raman spectroscopy

Raman spectroscopy is a well-known analytical technique for identifying and analyzing chemical species. Since Raman scattering is a weak effect, surface-enhanced Raman spectroscopy (SERS) is often employed to amplify the signal. SERS signal surface mapping is a common method for detecting trace amounts of target molecules. Since the method produce large amounts of data and, in the case of very low concentrations, low signal-to-noise (SNR) ratio, ability to extract relevant spectral features is crucial. We propose a pseudo-Voigt model as a constrained source separation model, that is able to directly and reliably identify the Raman modes, with overall performance similar to the state of the art non-negative matrix factorization approach. However, the model provides better interpretation and is a step towards enabling the use of SERS in detection of trace amounts of molecules in real-life settings.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Alstrøm, T. S. (Intern), Schmidt, M. N. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern), Larsen, J. (Intern)
Pages: 2317-21
Publication date: 2017

Bayesian inference for spatio-temporal spike-and-slab priors

In this work, we address the problem of solving a series of underdetermined linear inverse problemblems subject to a sparsity constraint. We generalize the spike-and-slab prior distribution to encode a priori correlation of the support of the solution in both space and time by imposing a transformed Gaussian process on the spike-and-slab probabilities. An expectation propagation (EP) algorithm for posterior inference under the proposed model is derived. For large scale problems, the standard EP algorithm can be prohibitively slow. We therefore introduce three different approximation schemes to reduce the computational complexity. Finally, we demonstrate the proposed model using numerical experiments based on both synthetic and real data sets.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Aalto University
Authors: Andersen, M. R. (Intern), Vehtari, A. (Ekstern), Winther, O. (Intern), Hansen, L. K. (Intern)
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Bayesian Modelling of Functional Whole Brain Connectivity

This thesis deals with parcellation of whole-brain functional magnetic resonance imaging (fMRI) using Bayesian inference with mixture models tailored to the fMRI data. In the three included papers and manuscripts, we analyze two different approaches to modeling fMRI signal; either we accept the prevalent strategy of standardizing of fMRI time series and model data using directional statistics or we model the variability in the signal across the brain and across multiple subjects. In either case, we use Bayesian nonparametric modeling to automatically learn from the fMRI data the number of functional units, i.e. parcels. We benchmark the proposed mixture models against state of the art methods of brain parcellation, both probabilistic and non-probabilistic.

The time series of each voxel are most often standardized using z-scoring which projects the time series data onto a hypersphere. This underlying manifold is often ignored and the data is modeled using Gaussian distributions. In one contribution, we show that using a mixture model based on the directional distribution, the von Mises-Fisher distribution, increase the reliability of inferred parcellations.

We develop a mixture model for modeling time-series using a Gaussian Process as a prior that is informed of the temporal dynamics of the data expected from the blood oxygenation level dependent (BOLD) signal. In two contributions, we explore the potential of this modeling framework. In the first, we show that this mixture model can delineate regions of task activation that can then be identified unsupervised. This forms a promising framework for unsupervised identification of task activated when the task design is unknown. In the final contribution, we evaluate the performance of the mixture
model on the problem of clustering whole-brain fMRI. Based on both simulations on synthetic data and analysis of two fMRI datasets, we show that the model provides improved reliability of clustering compared to traditional clustering methods. Furthermore, the inferred parcellations provide the foundation for a method for increasing the reliability and sensitivity in analyses of task activation and for determining the networks of functionally connectivity in fMRI.

The proposed mixture models form promising tools for brain parcellation and we hope the methods can provide a nudge towards using probabilistic models for fMRI parcellation.

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Authors: Røge, R. (Intern), Mørup, M. (Intern), Schmidt, M. N. (Intern)
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Bayesian state prediction of wind turbine bearing failure
A statistical approach to abstract and predict turbine states in an online manner has been developed. Online inference is performed on temperature measurement residuals to predict the failure state 5n steps ahead of time. In this framework a case study is performed showing the ability to predict bearing failure 33 days, on average, ahead of time. The approach is based on the separability of the sufficient statistics and a hidden variable, namely the state length. The predictive probability is conditioned on the data available, as well as the state variables. It is shown that the predictive probability can be calculated by a model for the samples and a hazard function describing the probability for undergoing a state transition. This study is concerned with the prior training of the model, for which run-to-failure time series of bearing measurements are used. For the sample model prediction is conditioned on prior information and predict the next 5n samples from a feature space spanned by the prior samples. By assuming that the feature space can be described by a multivariate Gaussian distribution, the prediction is treated as a Gaussian process over the feature space.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Siemens Wind Power A/S, University of Southern Denmark
Authors: Herp, J. (Forskerdatabase), Ramezani, M. H. (Ekstern), Bach-Andersen, M. (Intern), Pedersen, N. L. (Ekstern), Nadimi, E. S. (Ekstern)
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Authors: Hansen, V. L. (Intern)
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Can smartphone-based electronic markers discriminate between patients with bipolar disorder, healthy first-degree relatives and healthy control individuals

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Authors: Stanislaus, S. (Ekstern), Faurholt-Jepsen, M. (Ekstern), Vinberg, M. (Ekstern), Winther, O. (Intern), Frost, M. G. (Intern), Bardram, J. E. (Intern), Kessing, L. (Ekstern)
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Class attendance, peer similarity, and academic performance in a large field study

Identifying the factors that determine academic performance is an essential part of educational research. Existing research indicates that class attendance is a useful predictor of subsequent course achievements. The majority of the literature is, however, based on surveys and self-reports, methods which have well-known systematic biases that lead to limitations on conclusions and generalizability as well as being costly to implement. Here we propose a novel method for measuring class attendance that overcomes these limitations by using location and bluetooth data collected from smartphone sensors. Based on measured attendance data of nearly 1,000 undergraduate students, we demonstrate that early and consistent class attendance strongly correlates with academic performance. In addition, our novel dataset allows us to determine that attendance among social peers was substantially correlated (>0.5), suggesting either an important peer effect or homophily with respect to attendance.
CloudScan - A Configuration-Free Invoice Analysis System Using Recurrent Neural Networks

We present CloudScan; an invoice analysis system that requires zero configuration or upfront annotation. In contrast to previous work, CloudScan does not rely on templates of invoice layout, instead it learns a single global model of invoices that naturally generalizes to unseen invoice layouts. The model is trained using data automatically extracted from end-user provided feedback. This automatic training data extraction removes the requirement for users to annotate the data precisely. We describe a recurrent neural network model that can capture long range context and compare it to a baseline logistic regression model corresponding to the current CloudScan production system. We train and evaluate the system on 8 important fields using a dataset of 326,471 invoices. The recurrent neural network and baseline model achieve 0.891 and 0.887 average F1 scores respectively on seen invoice layouts. For the harder task of unseen invoice layouts, the recurrent neural network model outperforms the baseline with 0.840 average F1 compared to 0.788.

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Contact activity and dynamics of the social core

Humans interact through numerous communication channels to build and maintain social connections: they meet face-to-face, make phone calls or send text messages, and interact via social media. Although it is known that the network of physical contacts, for example, is distinct from the network arising from communication events via phone calls and instant messages, the extent to which these networks differ is not clear. We show here that the network structure of these channels show large structural variations. The various channels account for diverse relationships between pairs of individuals and the corresponding interaction patterns across channels differ to an extent that social ties cannot easily be reduced to a single layer. Each network of interactions, however, contains both central and peripheral individuals: central members are characterized by higher connectivity and can reach a large fraction of the network within a low number of steps, in contrast to the nodes on the periphery. The origin and purpose of each communication network also determine the role of their respective central members: highly connected individuals in the person-to-person networks interact with their environment in a regular manner, while members central in the social communication networks display irregular behavior with respect to their physical contacts and are more active through irregular social events. Our results suggest that due to the inherently different functions of communication channels, each one favors different social behaviors and different strategies for interacting with the environment. These findings can facilitate the understanding of the varying roles and impact individuals have on the population, which can further shed light on the prediction and prevention of epidemic outbreaks, or information propagation.

Correlations between human mobility and social interaction reveal general activity patterns

A day in the life of a person involves a broad range of activities which are common across many people. Going beyond diurnal cycles, a central question is: to what extent do individuals act according to patterns shared across an entire population? Here we investigate the interplay between different activity types, namely communication, motion, and physical proximity by analyzing data collected from smartphones distributed among 638 individuals. We explore two central questions: Which underlying principles govern the formation of the activity patterns? Are the patterns specific to
each individual or shared across the entire population? We find that statistics of the entire population allows us to successfully predict 71% of the activity and 85% of the inactivity involved in communication, mobility, and physical proximity. Surprisingly, individual level statistics only result in marginally better predictions, indicating that a majority of activity patterns are shared across our sample population. Finally, we predict short-term activity patterns using a generalized linear model, which suggests that a simple linear description might be sufficient to explain a wide range of actions, whether they be of social or of physical character.

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Organisations: Copenhagen Center for Health Technology, Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Mollgaard, A. (Ekstern), Jørgensen, S. L. (Intern), Mathiesen, J. (Ekstern)
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Data Mining and Visualization of Large Human Behavior Data Sets

Traditional methods for studying human behavior such as surveys and manual collection are expensive, time-consuming and therefore cannot be easily applied at large scale. In recent years an explosive amount of digital traces of human activity – for example social network interactions, emails and credit card transactions – have provided us new sources for studying our behavior. In particular smartphones have emerged as new tools for collecting data about human activity, thanks to their sensing capabilities and their ubiquity. This thesis investigates the question of what we can learn about human behavior from this rich and pervasive mobile sensing data. In the first part, we describe a large-scale data collection deployment collecting high-resolution data for over 800 students at the Technical University of Denmark using smartphones, including location, social proximity, calls and SMS. We provide an overview of the technical infrastructure, the experimental design, and the privacy measures. The second part investigates the usage of this mobile sensing data for understanding personal behavior. We describe two large-scale user studies on the deployment of self-tracking apps, in order to understand the patterns of usage and non-usage. Moreover we provide some design guidelines for facilitating reflection in self-tracking systems. Finally we propose a model for inferring sleep patterns from smartphone interactions.

In the third part, we focus on a specific aspect of collective behavior: human mobility. We perform an experiment to verify the feasibility of inferring places from location traces using mobile sensing data. We develop a hierarchical model for human mobility, which is able to measure mobility properties at multiple scales. We perform a study on the factors influencing the accuracy of nextplace prediction models. Finally we present an open-source tool for creating geographical visualizations.

Deep convolutional neural networks for interpretable analysis of EEG sleep stage scoring

Sleep studies are important for diagnosing sleep disorders such as insomnia, narcolepsy or sleep apnea. They rely on manual scoring of sleep stages from raw polysomnography signals, which is a tedious visual task requiring the workload of highly trained professionals. Consequently, research efforts to pursue for an automatic stage scoring based on machine
learning techniques have been carried out over the last years. In this work, we resort to multitaper spectral analysis to create visually interpretable images of sleep patterns from EEG signals as inputs to a deep convolutional network trained to solve visual recognition tasks. As a working example of transfer learning, a system able to accurately classify sleep stages in new unseen patients is presented. Evaluations in a widely-used publicly available dataset favourably compare to state-of-the-art results, while providing a framework for visual interpretation of outcomes.

DeepLoc: prediction of protein subcellular localization using deep learning
The prediction of eukaryotic protein subcellular localization is a well-studied topic in bioinformatics due to its relevance in proteomics research. Many machine learning methods have been successfully applied in this task, but in most of them, predictions rely on annotation of homologues from knowledge databases. For novel proteins where no annotated homologues exist, and for predicting the effects of sequence variants, it is desirable to have methods for predicting protein properties from sequence information only. Here, we present a prediction algorithm using deep neural networks to predict protein subcellular localization relying only on sequence information. At its core, the prediction model uses a recurrent neural network that processes the entire protein sequence and an attention mechanism identifying protein regions important for the subcellular localization. The model was trained and tested on a protein dataset extracted from one of the latest UniProt releases, in which experimentally annotated proteins follow more stringent criteria than previously. We demonstrate that our model achieves a good accuracy (78% for 10 categories; 92% for membrane-bound or soluble), outperforming current state-of-the-art algorithms, including those relying on homology information. The method is available as a web server at http://www.cbs.dtu.dk/services/DeepLoc. Example code is available at https://github.com/JJAlmagro/subcellular_localization. The dataset is available at http://www.cbs.dtu.dk/services/DeepLoc/data.php. jjalma@dtu.dk.
Deep recurrent conditional random field network for protein secondary prediction

Deep learning has become the state-of-the-art method for predicting protein secondary structure from only its amino acid residues and sequence profile. Building upon these results, we propose to combine a bi-directional recurrent neural network (biRNN) with a conditional random field (CRF), which we call the biRNN-CRF. The biRNN-CRF may be seen as an improved alternative to an autoregressive uni-directional RNN where predictions are performed sequentially conditioning on the prediction in the previous timestep. The CRF is instead nearest neighbor-aware and models for the joint distribution of the labels for all time-steps. We condition the CRF on the output of biRNN, which learns a distributed representation based on the entire sequence. The biRNN-CRF is therefore close to ideally suited for the secondary structure task because a high degree of cross-talk between neighboring elements can be expected. We validate the model on several benchmark datasets. For example, on CB513, a model with 1.7 million parameters, achieves a Q8 accuracy of 69.4 for single model and 70.9 for ensemble, which to our knowledge is state-of-the-art. 1

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Organisations: Department of Applied Mathematics and Computer Science, Copenhagen Center for Health Technology, Cognitive Systems, University of Copenhagen
Difference-of-Convex optimization for variational kl-corrected inference in dirichlet process mixtures

Variational methods for approximate inference in Bayesian models optimise a lower bound on the marginal likelihood, but the optimization problem often suffers from being nonconvex and high-dimensional. This can be alleviated by working in a collapsed domain where a part of the parameter space is marginalized. We consider the KL-corrected collapsed variational bound and apply it to Dirichlet process mixture models, allowing us to reduce the optimization space considerably. We find that the variational bound exhibits consistent and exploitable structure, allowing the application of difference-of-convex optimization algorithms. We show how this yields an interpretable fixed-point update algorithm in the collapsed setting for the Dirichlet process mixture model. We connect this update formula to classical coordinate ascent updates, illustrating that the proposed improvement surprisingly reduces to the traditional scheme.

Dynamical Functional Theory for Compressed Sensing

We introduce a theoretical approach for designing generalizations of the approximate message passing (AMP) algorithm for compressed sensing which are valid for large observation matrices that are drawn from an invariant random matrix ensemble. By design, the fixed points of the algorithm obey the Thouless-Anderson-Palmer (TAP) equations corresponding to the ensemble. Using a dynamical functional approach we are able to derive an effective stochastic process for the marginal statistics of a single component of the dynamics. This allows us to design memory terms in the algorithm in such a way that the resulting fields become Gaussian random variables allowing for an explicit analysis. The asymptotic statistics of these fields are consistent with the replica ansatz of the compressed sensing problem.
EEG Based Inference of Spatio-Temporal Brain Dynamics

Electroencephalography (EEG) provides a measure of brain activity and has improved our understanding of the brain immensely. However, there is still much to be learned and the full potential of EEG is yet to be realized. In this thesis we suggest to improve the information gain of EEG using three different approaches; 1) by recovery of the EEG sources, 2) by representing and inferring the propagation path of EEG sources, and 3) by combining EEG with functional magnetic resonance imaging (fMRI). The common goal of the methods, and thus of this thesis, is to improve the spatial dimension of EEG.

The main topic of this thesis is the localization of the EEG generators. This entails solving both a forward and an inverse problem. The inverse problem maps the EEG signal recorded on the scalp to its origin in the brain. It is a highly ill-posed problem which we tackle by employing a sparsity promoting ‘spike and slab’ like method augmented with physiologically relevant source priors. The incorporated temporal and spatial priors exploit coherence between neighboring time samples and between neighboring source locations, respectively. We show that these augmentations effectively increase the source recovery ability.

The forward problem describes the propagation of neuronal activity in the brain to the EEG electrodes on the scalp. The geometry and conductivity of the head layers are normally required to model this path. We propose a framework for inferring forward models which is based on the EEG signal and a low dimensional representation of forward models. The representation is built by principal component analysis of a corpus of forward models. The method can be used to recover subject-specific forward models when structural scans and/or conductivity estimations are not available.

Finally we investigate the extraction of EEG components having bandpower dynamics correlated with fMRI components. We show that adding anatomical information to the inference scheme improves the recovery of correlated components compared to only using functional information. The anatomical information is incorporated through the EEG forward model and assumes that the activity of the fMRI component overlaps spatially with the origin of the coupled EEG component.
We performed simultaneous recordings of electroencephalography (EEG) from multiple students in a classroom, and measured the inter-subject correlation (ISC) of activity evoked by a common video stimulus. The neural reliability, as quantified by ISC, has been linked to engagement and attentional modulation in earlier studies that used high-grade equipment in laboratory settings. Here we reproduce many of the results from these studies using portable low-cost equipment, focusing on the robustness of using ISC for subjects experiencing naturalistic stimuli. The present data shows that stimulus-evoked neural responses, known to be modulated by attention, can be tracked for groups of students with synchronized EEG acquisition. This is a step towards real-time inference of engagement in the classroom.
EEG source imaging assists decoding in a face recognition task

EEG based brain state decoding has numerous applications. State of the art decoding is based on processing of the multivariate sensor space signal, however evidence is mounting that EEG source reconstruction can assist decoding. EEG source imaging leads to high-dimensional representations and rather strong a priori information must be invoked. Recent work by Edelman et al. (2016) has demonstrated that introduction of a spatially focal source space representation can improve decoding of motor imagery. In this work we explore the generality of Edelman et al. hypothesis by considering decoding of face recognition. This task concerns the differentiation of brain responses to images of faces and scrambled faces and poses a rather difficult decoding problem at the single trial level. We implement the pipeline using spatially focused features and show that this approach is challenged and source imaging does not lead to an improved decoding. We design a distributed pipeline in which the classifier has access to brain wide features which in turn does lead to a 15% reduction in the error rate using source space features. Hence, our work presents supporting evidence for the hypothesis that source imaging improves decoding.

Effective connectivity and gamma oscillations in a group at risk of psychosis

22q11.2 Deletion Syndrome (22q11.2DS) has been shown to be associated with a markedly increased risk for schizophrenia. Therefore, 22q11.2DS is a homogeneous genetic liability model which enables studies intending to identify functional abnormalities that may precede disease onset of schizophrenia. Being able to define these functional abnormalities could potentially assist in the search of biomarkers for schizophrenia. These are highly desired since early notification as well as early treatment have shown positive effects on everyday functioning in schizophrenia patients.

This thesis aimed at looking for functional abnormalities, known to be found in schizophrenia, in a cohort of 22q11.2 deletion carriers. The search for functional abnormalities in the 22q11.2 deletion syndrome cohort, were carried out measuring EEG while subjects engaged in a roving mismatch negativity (MMN) paradigm as well as an auditory steady state paradigm. Both of these paradigms are known to involve processes that are impaired in schizophrenia. This thesis ties together the three main contributions which are divided into three studies. In the first study, the responses to a roving MMN paradigm were assessed in 22q11.2 deletion carriers and healthy controls. Both conventional analysis of the MMN responses as well as a more sophisticated approach by means of Dynamic Causal Modelling (DCM) were carried out. DCM is a technique to extract effective connectivity between pre-specified brain areas. With this technique we investigated the underlying network of change detection in the two groups. While we found no indication of a reduced MMN response at the scalp level in the 22q11.2 deletion carriers, the underlying network of change detection differed as compared to healthy controls.
Second study extended study number one by employing a parametric DCM to study the underlying network of repetition suppression in 22q11.2 deletion carriers and healthy controls. While results for the control group indicated a processing in accordance with the predictive coding theory, this was not the case for the 22q11.2 deletion carriers.

Finally, in the third study the ability to generate 40 Hz cortical oscillations were assessed in 22q11.2 deletion carriers as well as healthy controls using an auditory steady state paradigm. Here, it was found that both phase and power of the 40 Hz oscillatory activity were reduced in 22q11.2 deletion carriers as compared to healthy controls.

In the three studies, results both similar and dissimilar to what is observed in the schizophrenia literature were found. The studies contribute in understanding the underlying pathology of 22q11.2 deletion syndrome and if results are confirmed by longitudinal follow up studies, the results might contribute in the search of biomarkers for schizophrenia.
End-to-end information extraction without token-level supervision

Most state-of-the-art information extraction approaches rely on token-level labels to find the areas of interest in text. Unfortunately, these labels are time-consuming and costly to create, and consequently, not available for many real-life IE tasks. To make matters worse, token-level labels are usually not the desired output, but just an intermediary step. End-to-end (E2E) models, which take raw text as input and produce the desired output directly, need not depend on token-level labels. We propose an E2E model based on pointer networks, which can be trained directly on pairs of raw input and output text. We evaluate our model on the ATIS data set, MIT restaurant corpus and the MIT movie corpus and compare to neural baselines that do use token-level labels. We achieve competitive results, within a few percentage points of the baselines, showing the feasibility of E2E information extraction without the need for token-level labels. This opens up new possibilities, as for many tasks currently addressed by human extractors, raw input and output data are available, but not token-level labels.

General information
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Authors: Palm, R. B. (Intern), Hovy, D. (Forskerdatabase), Laws, F. (Ekstern), Winther, O. (Intern)
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Enhancing User Experience in Next Generation Mobile Devices Using Eye Tracking as a Biometric Sensor

A good User Experience is not about just “getting the job done” in the most efficient way. It is also about the subjective elements, providing a positive experience to the user while doing so; emotionally and affectively, having the user engage with the service or product.

Knowing when this takes place means we need ways of measuring concepts like attention. The basis for this should preferably be rooted in our understanding of the anatomically based attention networks of the brain.
This thesis looks at biometric markers of cognitive and affective processes; at the overview level Electroencephalography (EEG), Galvanic Skin Conductance (GSR), Heart Rate and Heart Rate Variability as well as Face Expression Detection – and in much more detail Eye Tracking.

A simple framework for relating eye movements and pupil dilations to the visual processing system and to the attentional networks is suggested. It is demonstrated that it is possible to identify components of attention and cognitive load using low cost eye tracking in conventional office settings. It is also shown that aspects of surprise, similar to negativity feedback error coding, is measurable. Behavioural patterns possibly related to time on target, cognitive load, performance or stimuli are inferred. The existence of possibly unique individual gaze patterns related to visual stimuli or to the brain’s Default Mode Network are shown.

A way of synchronizing EEG and Eye Tracking is also suggested, and in addition, a few software assets (a Python interface to The Eye Tribe tracker and an implementation of the Attention Network Test (ANT)) have been created.

Evidence of complex contagion of information in social media: An experiment using Twitter bots
It has recently become possible to study the dynamics of information diffusion in techno-social systems at scale, due to the emergence of online platforms, such as Twitter, with millions of users. One question that systematically recurs is whether information spreads according to simple or complex dynamics: does each exposure to a piece of information have an independent probability of a user adopting it (simple contagion), or does this probability depend instead on the number of sources of exposure, increasing above some threshold (complex contagion)? Most studies to date are observational and, therefore, unable to disentangle the effects of confounding factors such as social reinforcement, homophily, limited attention, or network community structure. Here we describe a novel controlled experiment that we performed on Twitter using ‘social bots’ deployed to carry out coordinated attempts at spreading information. We propose two Bayesian statistical models describing simple and complex contagion dynamics, and test the competing hypotheses. We provide experimental evidence that the complex contagion model describes the observed information diffusion behavior more accurately than simple contagion. Future applications of our results include more effective defenses against malicious propaganda campaigns on social media, improved marketing and advertisement strategies, and design of effective network intervention techniques.
Examination of heterogeneous societies: Identifying subpopulations by contrasting cultures
The recent development of data analytic tools rooted around the Multi-Group Latent Class Analysis (MGLCA) has enabled the examination of heterogeneous datasets in a cross-cultural context. Although the MGLCA is considered as an established and popular cross-cultural data analysis approach, the infinite relational model (IRM) is a new and disruptive type of unsupervised clustering approach that has been developed recently by cognitive psychologists and computer scientists. In this article, an extended version of the IRM coined the multinominal IRM—or mIRM in short—is applied to a cross-cultural analysis of survey data available from the World Value Survey organization. Specifically, the present work analyzes response patterns of the Portrait Value Questionnaire (PVQ) representing Schwartz’s 10 basic values of Japanese and Swedes. The applied model exposes heterogeneous structures of the two societies consisting of fine-grained response patterns expressed by the respective subpopulations and extracts latent typological structures contrasting and highlighting similarities and differences between these two societies. In the final section, we discuss similarities and differences identified between the MGLCA and the mIRM approaches, which indicate potential applications and contributions of the mIRM and the general IRM framework for future cross-cultural data analyses.

General information
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Scopus rating (2013): SJR 0.96 SNIP 1.286 CiteScore 1.81
BFI (2012): BFI-level 2
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Scopus rating (2010): SJR 1.322 SNIP 1.548
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.091 SNIP 1.521
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Scopus rating (2008): SJR 1.234 SNIP 1.569
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Scopus rating (2006): SJR 1.614 SNIP 1.74
Scopus rating (2005): SJR 1.248 SNIP 1.061
Scopus rating (2004): SJR 1.064 SNIP 1.419
Excavating the mother lode of human-generated text: A systematic review of research that uses the Wikipedia corpus

Although primarily an encyclopedia, Wikipedia’s expansive content provides a knowledge base that has been continuously exploited by researchers in a wide variety of domains. This article systematically reviews the scholarly studies that have used Wikipedia as a data source, and investigates the means by which Wikipedia has been employed in three main computer science research areas: information retrieval, natural language processing, and ontology building. We report and discuss the research trends of the identified and examined studies. We further identify and classify a list of tools that can be used to extract data from Wikipedia, and compile a list of currently available data sets extracted from Wikipedia.
Fostering Bilateral Patient-Clinician Engagement in Active Self-Tracking of Subjective Experience

In this position paper we describe select aspects of our experience with health-related self-tracking, the data generated, and processes surrounding those. In particular we focus on how bilateral patient-clinician engagement may be fostered by the combination of technology and method. We exemplify with a case study where a PTSD-suffering veteran has been self-tracking a specific symptom precursor. The availability of high-resolution self-tracking data on the occurrences of even a single symptom created new opportunities in the therapeutic process for identifying underlying triggers of symptoms. The patient was highly engaged in self-tracking and sharing the collected data. We suggest a key reason was the collaborative effort in defining the data collection protocol and discussion of the data. The therapist also engaged highly in the self-tracking data, as it supported the existing therapeutic process in reaching insights otherwise unobtainable.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Konsulent Blomseth, Danish Defence Military Psychology Unit
Authors: Larsen, J. E. (Intern), Christiansen, T. B. (Ekstern), Eskelund, K. (Ekstern)
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From concept to in vivo testing: Microcontainers for oral drug delivery
This work explores the potential of polymeric micrometer sized devices (microcontainers) as oral drug delivery systems (DDS). Arrays of detachable microcontainers (D-MCs) were fabricated on a sacrificial layer to improve the handling and facilitate the collection of individual D-MCs. A model drug, ketoprofen, was loaded into the microcontainers using supercritical CO2 impregnation, followed by deposition of an enteric coating to protect the drug from the harsh gastric environment and to provide a fast release in the intestine. In vitro, in vivo and ex vivo studies were performed to assess the viability of the D-MCs as oral DDS. D-MCs improved the relative oral bioavailability by 180% within 4h, and increased the absorption rate by 2.4 times compared to the control. This work represents a significant step forward in the translation of these devices from laboratory to clinic.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Physics, Neutrons and X-rays for Materials Physics, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, University of Copenhagen
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Scopus rating (2017): SNIP 1.802 SJR 2.684
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Scopus rating (2016): CiteScore 7.56 SJR 2.463 SNIP 1.85
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.738 SNIP 2.074 CiteScore 8.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.438 SNIP 2.092 CiteScore 6.86
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Scopus rating (2013): SJR 2.441 SNIP 2.023 CiteScore 6.31
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ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.763 SNIP 2.089 CiteScore 6.33
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.225 SNIP 2.307
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 2.922 SNIP 2.033
Web of Science (2009): Indexed yes
From Raw Data to Social Systems - Separating the Signal from the Noise in Smartphone Sensor Measurements

Digital tools for communication and information exchange have been ingrained in our lives. We google our information and we skype our parents. We use the Internet to shop for groceries, do banking, and study. We play massively multiplayer online games, belong to online communities, and date online. However, this does not mean that our lives have really moved to the digital domain. Even though the Internet makes it possible to exist without ever leaving the confines our of bedrooms, we still choose to meet our friends in person or to travel through physical, rather than virtual, space. There is a richness to personal contact and direct experience that has not yet been replaced by the digital services. Until this shift happens, we continue to analyze and investigate our offline lives in the pursuit for deepening our understaning of human nature. Digital breadcrumbs, which we leave behind with every online action, are relatively easy to collect. Capturing our offline behaviors, on the other hand, is not trivial. Scientist often rely on data that approximates only one aspect of our lives. For example, mobile operator logs reveal who we call, but not who me meet. An alternative approach is to derive proxies of certain behaviors from smartphone sensor readings. Copenhagen Networks Study (CNS) employs this method, among others, to build the biggest dataset of the kind available to researchers in academia. The thesis shows a path from collecting raw smartphone data for CNS, through extracting increasingly meaningul information, to gaining novel insights into human behavior. Step by step, I turn a cryptic and seemingly uninteresting collection of hardware identifiers and received signal strenghts into a detailed record of people’s lives: where they go, who they encounter, who they become friends with. I compare their offline activities and social ties to their online representations and find a surprisingly small overlap. The methods I propose the thesis constitute a more privacy-aware alternative to currently employed social sensing approaches. I show how to track the mobility and interactions of participants without sharing the results with third parties inadvertently. At the same time, the findings presented in this thesis emphasize the fragility of our privacy: the data we today consider as safe to share today, tomorrow might prove to carry rich information about our lives.
Gaussian process based independent analysis for temporal source separation in fMRI

Functional Magnetic Resonance Imaging (fMRI) gives us a unique insight into the processes of the brain, and opens up for analyzing the functional activation patterns of the underlying sources. Task-inferred supervised learning with restrictive assumptions in the regression set-up, restricts the exploratory nature of the analysis. Fully unsupervised independent component analysis (ICA) algorithms, on the other hand, can struggle to detect clear classifiable components on single-subject data. We attribute this shortcoming to inadequate modeling of the fMRI source signals by failing to incorporate its temporal nature. fMRI source signals, biological stimuli and non-stimuli-related artifacts are all smooth over a time-scale compatible with the sampling time (TR). We therefore propose Gaussian process ICA (GPICA), which facilitates temporal dependency by the use of Gaussian process source priors. On two fMRI data sets with different sampling frequency, we show that the GPICA-inferred temporal components and associated spatial maps allow for a more definite interpretation than standard temporal ICA methods. The temporal structures of the sources are controlled by the covariance of the Gaussian process, specified by a kernel function with an interpretable and controllable temporal length scale parameter. We propose a hierarchical model specification, considering both instantaneous and convolutive mixing, and we infer source spatial maps, temporal patterns and temporal length scale parameters by Markov Chain Monte Carlo. A companion implementation made as a plug-in for SPM can be downloaded from https://github.com/dittehald/GPICA.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Department of Informatics and Mathematical Modeling, Cognitive Systems
Authors: Hald, D. H. (Intern), Henao, R. (Intern), Winther, O. (Intern)
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Scopus rating (2014): SJR 4.323 SNIP 2.03 CiteScore 6.9
Web of Science (2014): Indexed yes
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Scopus rating (2012): SJR 4.026 SNIP 1.972 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
The goal of this thesis is to explore two improvements for functional magnetic resonance imaging (fMRI) analysis; namely our proposed decomposition method and an extension to the non-parametric testing framework. Analysis of fMRI allows researchers to investigate the functional processes of the brain, and provides insight into neuronal coupling during mental processes or tasks.

The decomposition method is a Gaussian process-based independent components analysis (GPICA), which incorporates a temporal dependency in the sources. A hierarchical model specification is used, featuring both instantaneous and convolutive mixing, and the inferred temporal patterns. Spatial maps are seen to capture smooth and localized stimulus-related components, and often identifiable noise components. The implementation is freely available as a GUI/SPM plugin, and we recommend using GPICA as an additional tool when performing ICA on fMRI data to investigate the effect of the temporal source prior.

In fMRI, statistical tests are used to investigate the significance of activation in specific brain regions. By extending the non-parametric testing framework to incorporate functional prior knowledge, an increase in sensitivity can be achieved, entailing better evaluations and conclusions. The functional prior knowledge is incorporated by use of a proposed Graph-Based Cluster Permutation Test (GBCPT), entailing the possibility to expand the use of cluster permutations to multiple applications, wherever a graph-based setup can be used.

Generative Temporal Modelling of Neuroimaging - Decomposition and Nonparametric Testing

The goal of this thesis is to explore two improvements for functional magnetic resonance imaging (fMRI) analysis; namely our proposed decomposition method and an extension to the non-parametric testing framework. Analysis of fMRI allows researchers to investigate the functional processes of the brain, and provides insight into neuronal coupling during mental processes or tasks.

The decomposition method is a Gaussian process-based independent components analysis (GPICA), which incorporates a temporal dependency in the sources. A hierarchical model specification is used, featuring both instantaneous and convolutive mixing, and the inferred temporal patterns. Spatial maps are seen to capture smooth and localized stimulus-related components, and often identifiable noise components. The implementation is freely available as a GUI/SPM plugin, and we recommend using GPICA as an additional tool when performing ICA on fMRI data to investigate the effect of the temporal source prior.

In fMRI, statistical tests are used to investigate the significance of activation in specific brain regions. By extending the non-parametric testing framework to incorporate functional prior knowledge, an increase in sensitivity can be achieved, entailing better evaluations and conclusions. The functional prior knowledge is incorporated by use of a proposed Graph-Based Cluster Permutation Test (GBCPT), entailing the possibility to expand the use of cluster permutations to multiple applications, wherever a graph-based setup can be used.
Gradient distortions in EEG provide motion tracking during simultaneous EEG-fMRI
Conference abstract, selected for oral presentation by Malte Laustsen.

Hearables in hearing care: discovering usage patterns through IoT devices
Hearables are on the rise as next generation wearables, capable of streaming audio, modifying soundscapes or functioning as biometric sensors. The recent introduction of IoT (Internet of things) connected hearing aids offer new opportunities for hearables to collect QS quantified self data that capture user intents and thereby provide insights to adjust the settings of the device. In our study 6 participants shared their QS data capturing when they remotely changed their device settings over 6 weeks. The data confirms that the participants preferred to actively change programs rather than use a single default setting provided by an audiologist. Furthermore, their unique usage patterns indicate a need for designing hearing aids, which as hearables adapt their settings dynamically to individual preferences during the day.
In this work, we present the investigation of the pyrolysis parameters at high temperature (1100 °C) for the fabrication of two-dimensional pyrolytic carbon electrodes. The electrodes were fabricated by pyrolysis of lithographically patterned negative epoxy based photoresist SU-8. A central composite experimental design was used to identify the influence of dwell time at the highest pyrolysis temperature and heating rate on electrical, electrochemical and structural properties of the pyrolytic carbon: Van der Pauw sheet resistance measurements, cyclic voltammetry, electrochemical impedance spectroscopy and Raman spectroscopy were used to characterize the pyrolytic carbon.

The results show that the temperature increase from 900 °C to 1100 °C improves the electrical and electrochemical properties. At 1100 °C, longer dwell time leads to lower resistivity, while the variation of the pyrolysis parameters has small influence on electrochemical performance.
Improved detection of chemical substances from colorimetric sensor data using probabilistic machine learning

We present a data-driven machine learning approach to detect drug- and explosives-precursors using colorimetric sensor technology for air-sampling. The sensing technology has been developed in the context of the CRIM-TRACK project. At present a fully-integrated portable prototype for air sampling with disposable sensing chips and automated data acquisition has been developed. The prototype allows for fast, user-friendly sampling, which has made it possible to produce large datasets of colorimetric data for different target analytes in laboratory and simulated real-world application scenarios. To make use of the highly multi-variate data produced from the colorimetric chip a number of machine learning techniques are employed to provide reliable classification of target analytes from confounders found in the air streams. We demonstrate that a data-driven machine learning method using dimensionality reduction in combination with a probabilistic classifier makes it possible to produce informative features and a high detection rate of analytes. Furthermore, the probabilistic machine learning approach provides a means of automatically identifying unreliable measurements that could produce false predictions. The robustness of the colorimetric sensor has been evaluated in a series of experiments focusing on the amphetamine pre-cursor phenylacetone as well as the improvised explosives pre-cursor hydrogen peroxide. The analysis demonstrates that the system is able to detect analytes in clean air and mixed with substances that occur naturally in real-world sampling scenarios. The technology under development in CRIM-TRACK has the potential as an effective tool to control trafficking of illegal drugs, explosive detection, or in other law enforcement applications.

General information

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Inferring human intentions from the brain data

The human brain is a massively complex organ composed of approximately a hundred billion densely interconnected, interacting neural cells. The neurons are not wired randomly - instead, they are organized in local functional assemblies. It is believed that the complex patterns of dynamic electric discharges across the neural tissue are responsible for emergence of high cognitive function, conscious perception and voluntary action. The brain’s capacity to exercise free will, or internally generated free choice, has long been investigated by philosophers, psychologists and neuroscientists. Rather than assuming a causal power of conscious will, the neuroscience of volition is based on the premise that “mental states rest on brain processes”, and hence by measuring spatial and temporal correlates of volition in carefully controlled experiments we can infer about their underlying mind processes, including concepts as intriguing as “free will”, “agency” and “consciousness”. Recent developments in electrophysiology and neuroimaging methods allow for increasingly more accurate estimation of spatial and temporal characteristics of decision processes.

The work presented in this thesis is intended to contribute to our understanding of the dynamics of voluntary decision processes about prospective action. In the two presented studies we probe different types of decisions and compare them in terms of behavioral and EEG characteristics. We show that decision processes are manifested by complex, broadband modulation of brain oscillatory patterns, primarily in Alpha (8-12Hz) and Beta (16-30Hz) ranges. Our results suggest that decisions about whether to act or not, what type of action to perform, and about the timing of the action have distinct dynamic representations, and thus are to some extent mediated by different neural components. Furthermore, free action can be partially explained by low level behavioral preferences, especially in contexts where no explicit incentive favors one action over another.

Apart from the investigation of volition, considerable part of the work presented in this thesis is dedicated to experiment design methodology and efficient EEG processing methods. We have developed a dedicated, flexible Virtual Reality Environment (VRE) platform, suitable for investigation of volition and action preparation processes with range of modalities, including electroencephalography (EEG), functional magnetic resonance (fMRI), eye-tracking (ET) and behavioral measures. By providing ecologically valid, semi-realistic experience we aimed at reinforcing the natural decision processes and minimize the problem of random-sequence generation and fatigue in participants undergoing highly repeatable cognitive experiments. Other methodological contributions presented in the thesis are related to efficient, automatized and highly data-preserving methods for processing of EEG data, based on minimal number of arbitrarily selected parameters.
Inferring Person-to-person Proximity Using WiFi Signals

Today’s societies are enveloped in an ever-growing telecommunication infrastructure. This infrastructure offers important opportunities for sensing and recording a multitude of human behaviors. Human mobility patterns are a prominent example of such a behavior which has been studied based on cell phone towers, Bluetooth beacons, and WiFi networks as proxies for location. However, while mobility is an important aspect of human behavior, understanding complex social systems requires studying not only the movement of individuals, but also their interactions. Sensing social interactions on a large scale is a technical challenge and many commonly used approaches—including RFID badges or Bluetooth scanning—offer only limited scalability. Here we show that it is possible, in a scalable and robust way, to accurately infer person-to-person physical proximity from the lists of WiFi access points measured by smartphones carried by the two individuals. Based on a longitudinal dataset of approximately 800 participants with ground-truth interactions collected over a year, we show that our model performs better than the current state-of-the-art. Our results demonstrate the value of WiFi signals in social sensing as well as potential threats to privacy that they imply.

Infinite von Mises-Fisher Mixture Modeling of Whole Brain fMRI Data

Cluster analysis of functional magnetic resonance imaging (fMRI) data is often performed using gaussian mixture models, but when the time series are standardized such that the data reside on a hypersphere, this modeling assumption is questionable. The consequences of ignoring the underlying spherical manifold are rarely analyzed, in part due to the computational challenges imposed by directional statistics. In this letter, we discuss a Bayesian von Mises-Fisher (vMF) mixture model for data on the unit hypersphere and present an efficient inference procedure based on collapsed Markov chain Monte Carlo sampling. Comparing the vMF and gaussian mixture models on synthetic data, we demonstrate that the vMF model has a slight advantage inferring the true underlying clustering when compared to gaussian-based models on data generated from both a mixture of vMFs and a mixture of gaussians subsequently normalized. Thus, when performing model selection, the two models are not in agreement. Analyzing multisubject whole brain resting-state fMRI data from healthy adult subjects, we find that the vMF mixture model is considerably more reliable than the gaussian mixture model when comparing solutions across models trained on different groups of subjects, and again we find that the two models disagree on the optimal number of components. The analysis indicates that the fMRI data support more than a thousand clusters, and we confirm this is not a result of overfitting by demonstrating better prediction on data from held-out subjects.
Our results highlight the utility of using directional statistics to model standardized fMRI data and demonstrate that whole brain segmentation of fMRI data requires a very large number of functional units in order to adequately account for the discernible statistical patterns in the data.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
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- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
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- Scopus rating (2013): SJR 0.827 SNIP 1.009 CiteScore 2.39
- ISI indexed (2013): ISI indexed yes
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- Scopus rating (2012): SJR 0.853 SNIP 1.36 CiteScore 2.48
- ISI indexed (2012): ISI indexed yes
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- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 1.312 SNIP 1.385 CiteScore 2.59
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- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 1.459 SNIP 1.68
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 1.283 SNIP 1.656
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- Scopus rating (2008): SJR 1.486 SNIP 1.674
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.633 SNIP 2.117
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 1.539 SNIP 2.465
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 1.609 SNIP 2.651
- Web of Science (2005): Indexed yes
- Scopus rating (2004): SJR 1.619 SNIP 2.453
- Scopus rating (2003): SJR 1.638 SNIP 2.53


Intrinsic Grassmann Averages for Online Linear and Robust Subspace Learning

Principal Component Analysis (PCA) is a fundamental method for estimating a linear subspace approximation to high-dimensional data. Many algorithms exist in literature to achieve a statistically robust version of PCA called RPCA. In this paper, we present a geometric framework for computing the principal linear subspaces in both situations that amounts to computing the intrinsic average on the space of all subspaces (the Grassmann manifold). Points on this manifold are defined as the subspaces spanned by K-tuples of observations. We show that the intrinsic Grassmann average of these subspaces coincide with the principal components of the observations when they are drawn from a Gaussian distribution. Similar results are also shown to hold for the RPCA. Further, we propose an efficient online algorithm to do subspace averaging which is of linear complexity in terms of number of samples and has a linear convergence rate. When the data has outliers, our proposed online robust subspace averaging algorithm shows significant performance (accuracy and computation time) gain over a recently published RPCA methods with publicly accessible code. We have demonstrated competitive performance of our proposed online subspace algorithm method on one synthetic and two real data sets. Experimental results depicting stability of our proposed method are also presented. Furthermore, on two real outlier corrupted datasets, we present comparison experiments showing lower reconstruction error using our online RPCA algorithm. In terms of reconstruction error and time required, both our algorithms outperform the competition.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Florida
Authors: Chakraborty, R. (Ekstern), Hauberg, S. (Intern), Vemuri, B. C. (Ekstern)
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Large Scale Computing for the Modelling of Whole Brain Connectivity

The human brain constitutes an impressive network formed by the structural and functional connectivity patterns between billions of neurons. Modern functional and diffusion magnetic resonance imaging (fMRI and dMRI) provides unprecedented opportunities for exploring the functional and structural organization of the brain in continuously increasing resolution. From these images, networks of structural and functional connectivity can be constructed. Bayesian stochastic block modelling provides a prominent data-driven approach for uncovering the latent organization, by clustering the networks into groups of nodes with a shared connectivity pattern. Modelling the brain in great detail on a whole-brain scale is essential to fully understand the underlying organization of the brain and reveal the relations between structure and function, that allows sophisticated cognitive behaviour to emerge from ensembles of neurons. Relying on Markov Chain Monte Carlo (MCMC) simulations as the workhorse in Bayesian inference however poses significant computational challenges, especially when modelling networks at the scale and complexity supported by high-resolution whole-brain MRI. In this thesis, we present how to overcome these computational limitations and apply Bayesian stochastic block models for unsupervised data-driven clustering of whole-brain connectivity in full image resolution. We implement high-performance software that allows us to efficiently apply stochastic blockmodelling with MCMC sampling on large complex
networks. To obtain the necessary computational performance, we find that both hardware and model specific properties must be taken into consideration - to an extend not supported by generic modelling tools. Computational overhead is reduced by an approach, where key values are cached to avoid re-computations, while tablelookups are utilized for frequently computed special functions. The efficient memory-management of C++ is utilized to implement dedicated data-structures, optimized to facilitate performance-critical operations related to the inference procedure. Furthermore, the software is based on a modular design, which allows us to couple and explore different models and sampling procedures in runtime, still being applied to full-sized data. Using the implemented tools, we demonstrate that the models successfully can be applied for clustering whole-brain connectivity networks. Without being informed of spatial information, the data-driven models can discover spatial homogeneous regions that are meaningful and in agreement with existing anatomical atlases. We further demonstrate that structural and functional connectivity share information, allowing us to jointly model both modalities. For limited, noisy fMRI data we find that integrating structural information aids in discovering the functional organization better than using the fMRI data alone. Though structure and function describes very different properties of the brain, we find that probabilistic modelling provides an intuitive data-driven approach for uncovering the latent organization in connectivity networks. We find that the stochastic block models can be computationally scaled to model wholebrain connectivity, and by doing so allows us to better utilize the full potential of high-resolution MRI and advances our understanding of both the functional and structural organization of the entire brain.

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Authors: Albers, K. J. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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Modeling Structural Brain Connectivity

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

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

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

The generation of structural brain connectivity graphs comprises a comprehensive processing pipeline, with various experimenter-defined parameters. The settings of these parameters are, however, unclear and this subjective aspect complicates the cross-comparison of studies investigating structural brain connectivity derived from tractography. Even though scan acquisition parameters, i.e. spatial resolution, angular resolution and b-value, are often discussed as possible factors influencing the final result, the impact of these factors on the derived structural connectivity graph has not yet been investigated. Herein, structural connectivity graphs, generated using different combinations of the three aforementioned acquisition parameters, are validated by comparison to a connectivity graph derived using invasive tracer injections in monkeys. It is found that the choice of acquisition parameters influences the derived structural connectivity graph and that higher angular resolution is always beneficial. Surprisingly, it is also found that higher spatial resolution does not improve the derived graph, but further investigation is needed to confirm this result.
Modeling the Temporal Nature of Human Behavior for Demographics Prediction

Mobile phone metadata is increasingly used for humanitarian purposes in developing countries as traditional data is scarce. Basic demographic information is however often absent from mobile phone datasets, limiting the operational impact of the datasets. For these reasons, there has been a growing interest in predicting demographic information from mobile phone metadata. Previous work focused on creating increasingly advanced features to be modeled with standard machine learning algorithms. We here instead model the raw mobile phone metadata directly using deep learning, exploiting the temporal nature of the patterns in the data. From high-level assumptions we design a data representation and convolutional network architecture for modeling patterns within a week. We then examine three strategies for aggregating patterns across weeks and show that our method reaches state-of-the-art accuracy on both age and gender prediction using only the temporal modality in mobile metadata. We finally validate our method on low activity users and evaluate the modeling assumptions.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Massachusetts Institute of Technology, Telenor Research
Authors: Felbo, B. (Ekstern), Sundsøy, P. (Ekstern), Pentland, A. (Ekstern), Jørgensen, S. L. (Intern), Montjoye, Y. (Ekstern)
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Modelling Digital Media Objects
The goal of this thesis is to investigate two relevant issues regarding computational representation and classification of digital multi-media objects. With a special focus on music, a model for representation of objects comprising multiple heterogeneous data types is investigated. Necessary to this work are considerations regarding integration of multiple diverse data modalities and evaluation of the resulting concept representation.

Regarding modelling of data exhibiting certain sequential structure, a number of theoretical and empirical results are presented. These are results related to model parameter estimation and the use of sequence models in a classification scenario. The latter being of importance in various digital multimedia navigation and retrieval tasks.

In the fields of topic modelling and multi-modal integration, we formulate a model to describe entities composed of multiple aspects. The particular aspects considered in the publications are sound, song lyrics, and user-provided metadata. This
model integrates the diverse data types comprising the objects and defines concrete unified representations in a joint "semantic" space. Within the context of this model, general measures of similarity between such multi-modal objects are investigated.

In the fields of method of moments and sequence modelling, we increase practical applicability of a certain moment based parameter estimation method for Hidden Markov models by showing how to use full-length sequences in the estimation process. Consequently, this impacts the quality of the estimated model parameters.

Subsequently, we show how to perform time series classification using a composite likelihood formulated from third order moments defined by the Hidden Markov model. Compared to the conventional likelihood based method, our contribution is less computationally expensive, while retaining the level of classification performance.

**Multi-scale spatio-temporal analysis of human mobility**

The recent availability of digital traces generated by phone calls and online logins has significantly increased the scientific understanding of human mobility. Until now, however, limited data resolution and coverage have hindered a coherent description of human displacements across different spatial and temporal scales. Here, we characterise mobility behaviour across several orders of magnitude by analysing similar to 850 individuals' digital traces sampled every similar to 16 seconds for 25 months with similar to 10 meters spatial resolution. We show that the distributions of distances and waiting times between consecutive locations are best described by log-normal and gamma distributions, respectively, and that natural time-scales emerge from the regularity of human mobility. We point out that log-normal distributions also characterise the patterns of discovery of new places, implying that they are not a simple consequence of the routine of modern life.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Troelsgaard, R. (Intern), Hansen, L. K. (Intern), Larsen, J. (Intern)
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**Multi-scale spatio-temporal analysis of human mobility**

The recent availability of digital traces generated by phone calls and online logins has significantly increased the scientific understanding of human mobility. Until now, however, limited data resolution and coverage have hindered a coherent description of human displacements across different spatial and temporal scales. Here, we characterise mobility behaviour across several orders of magnitude by analysing similar to 850 individuals’ digital traces sampled every similar to 16 seconds for 25 months with similar to 10 meters spatial resolution. We show that the distributions of distances and waiting times between consecutive locations are best described by log-normal and gamma distributions, respectively, and that natural time-scales emerge from the regularity of human mobility. We point out that log-normal distributions also characterise the patterns of discovery of new places, implying that they are not a simple consequence of the routine of modern life.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Center for Health Technology, University of London
Authors: Alessandretti, L. (Ekstern), Sapiezynski, P. (Intern), Jørgensen, S. L. (Intern), Baronchelli, A. (Ekstern)
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On the Keyhole Hypothesis: High Mutual Information between Ear and Scalp EEG

We propose and test the keyhole hypothesis that measurements from low dimensional EEG, such as ear-EEG reflect a broadly distributed set of neural processes. We formulate the keyhole hypothesis in information theoretical terms. The experimental investigation is based on legacy data consisting of 10 subjects exposed to a battery of stimuli, including alpha-attenuation, auditory onset, and mismatch-negativity responses and a new medium-long EEG experiment involving data acquisition during 13 h. Linear models were estimated to lower bound the scalp-to-ear capacity, i.e., predicting ear-EEG data from simultaneously recorded scalp EEG. A cross-validation procedure was employed to ensure unbiased estimates. We present several pieces of evidence in support of the keyhole hypothesis: There is a high mutual information
between data acquired at scalp electrodes and through the ear-EEG "keyhole," furthermore we show that the view represented as a linear mapping is stable across both time and mental states. Specifically, we find that ear-EEG data can be predicted reliably from scalp EEG. We also address the reverse view, and demonstrate that large portions of the scalp EEG can be predicted from ear-EEG, with the highest predictability achieved in the temporal regions and when using ear-EEG electrodes with a common reference electrode.

Open semantic analysis: The case of word level semantics in Danish
The present research is motivated by the need for accessible and efficient tools for automated semantic analysis in Danish. We are interested in tools that are completely open, so they can be used by a critical public, in public administration, non-governmental organizations and businesses. We describe data-driven models for Danish semantic relatedness, word intrusion and sentiment prediction. Open Danish corpora were assembled and unsupervised learning
implemented for explicit semantic analysis and with Gensim’s Word2vec model. We evaluate the performance of the two models on three different annotated word datasets. We test the semantic representations’ alignment with single word sentiment using supervised learning. We find that logistic regression and large random forests perform well with Word2vec features.

**General information**

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Authors: Nielsen, F. Å. (Intern), Hansen, L. K. (Intern)
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**Optimal allocation of reviewers for peer feedback**

Peer feedback is the act of letting students give feedback to each other on submitted work. There are multiple reasons to use peer feedback, including students getting more feedback, time saving for teachers and increased learning by letting students reflect on work by others. In order for peer feedback to be effective students should give and receive useful feedback. A key challenge in peer feedback is allocating the feedback givers in a good way. It is important that reviewers are allocated to submissions such that the feedback distribution is fair - meaning that all students receive good feedback.

In this paper we present a novel way to intelligently allocate reviewers for peer feedback. We train a statistical model to infer the quality of feedback based on a dataset of feedback quality evaluations. This dataset contains more than 20,000 reviews where the receiver of the feedback has indicated the quality of the feedback. Using this model together with historical data we calculate the feedback-giving skill of each student and uses that as input to an allocation algorithm that assigns submissions to reviewers, in order to optimize the feedback quality for all students.

We test the performance of our allocation strategy using real data from over 600 peer feedback sessions and simulate the effects of different allocation strategies. By comparing our method with a random allocation algorithm and a “super-informed oracle” algorithm we demonstrate that we are able to allocate reviewers to submissions in such a way that all submissions receive feedback of similar quality and that we are able to significantly outperform simple random allocation of reviewers. Additionally we investigate the effect of pre-allocating reviews in comparison to allocating reviewers live during the review process and show that live-allocation leads to better results. Our method is robust to reviews not being completed and other real-life quirks and improves as more feedback data is collected.

**General information**

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Phenomenological theory of collective decision-making
An essential task of groups is to provide efficient solutions for the complex problems they face. Indeed, considerable efforts have been devoted to the question of collective decision-making related to problems involving a single dominant feature. Here we introduce a quantitative formalism for finding the optimal distribution of the group members’ competences in the more typical case when the underlying problem is complex, i.e., multidimensional. Thus, we consider teams that are aiming at obtaining the best possible answer to a problem having a number of independent sub-problems. Our approach is based on a generic scheme for the process of evaluating the proposed solutions (i.e., negotiation). We demonstrate that the best performing groups have at least one specialist for each sub-problem but a far less intuitive result is that finding the optimal solution by the interacting group members requires that the specialists also have some insight into the sub-problems beyond their unique field(s). We present empirical results obtained by using a large-scale database of citations being in good agreement with the above theory. The framework we have developed can easily be adapted to a variety of realistic situations since taking into account the weights of the sub-problems, the opinions or the relations of the group is straightforward. Consequently, our method can be used in several contexts, especially when the optimal composition of a group of decision-makers is designed.
Probabilistic models for structured sparsity

Sparsity has become an increasingly popular choice of regularization in machine learning and statistics. The sparsity assumption for a matrix $X$ means that most of the entries in $X$ are equal to exactly zero. Structured sparsity is a generalization of sparsity and assumes that the set of locations of the non-zero coefficients in $X$ contains structure that can be exploited. This thesis deals with probabilistic models for structured sparsity for regularization of ill-posed problems. The aim of the thesis is two-fold; to construct sparsity promoting prior distributions for structured sparsity and to derive efficient inference algorithms for these distributions. The work explores a class of models that uses Gaussian processes (Rasmussen and Williams, 2006) as a latent representation of the structure of sparsity patterns. This representation allows prior knowledge of the structure of the sparsity patterns to be encoded using generic covariance functions through the Gaussian process. This thesis focuses on two specific instances of ill-posed problems: linear inverse problems and time-varying covariance estimation. The first part of the thesis deals with probabilistic methods for finding structured sparse solutions to linear inverse problems. In this part, the sparsity promoting prior known as the spike-and-slab prior (Mitchell and Beauchamp, 1988) is generalized to the structured sparsity setting. An expectation propagation algorithm is derived for approximate posterior inference. The proposed model and the associated inference algorithm are studied and evaluated using a set of numerical experiments, which include phase transition experiments, compressed sensing, phoneme classification and electroencephalography (EEG) source localization. The second part of the thesis deals with the problem of time-varying covariance estimation. A hierarchical model for a set of non-stationary time series with time-varying covariance matrices is proposed. The model is tailored to address the problem of dynamic functional connectivity in neuroimaging and it assumes that the instantaneous covariance matrix of each time series is decomposed into a non-negative linear combination of elements from a dictionary of shared covariance matrix components. A variational Bayes algorithm is derived for approximate posterior inference. The proposed model is validated using a functional magnetic resonance imaging (fMRI) dataset.

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The act of producing content - for example in forms of written reports - is one of the most used methods for teaching and learning all the way from primary school to university. It is a learning tool which helps students relate their theories to practice. Getting relevant and helpful feedback on this work is important to ensure a good learning experience for the students. Providing this feedback is often a time-consuming job for the teacher. An effective way to learn is to teach others, and similarly give feedback on work done by others. One way to approach a combined solution to the above challenges, is to use peer assessment in the classroom which as a learning method has become more and more popular. In this paper we look at data collected using the web-based peer assessment system Peergrade. The dataset consists of over 350 courses at more than 20 educational institutions and with a total of more than 10,000 students. The students have together made more than 100,000 peer-evaluations of work by other students, and these evaluations together contain more than 10,000,000 words of text feedback. A key problem when using peer assessment is to ensure high quality feedback between peers. Feedback here can be a combination of quantitative / summative feedback (numerical) and qualitative / formative feedback (text). A lot of work has been done on validating and ensuring quality of quantitative feedback. We propose a way to let students evaluate the quality of the feedback they receive to obtain a quality measure for the feedback. We investigate this measure of feedback quality, which biases are present and what trends can be observed across the dataset. Using our measure of feedback quality, we investigate how it relates to various factors like the length of the feedback text, the number of spelling mistakes, how positive it is and measures of the student's report-writing skills.

Functional magnetic resonance imaging (fMRI) is increasingly used to characterize functional connectivity between brain regions. Given the vast number of between-voxel interactions in high-dimensional fMRI data, it is an ongoing challenge to detect stable and generalizable functional connectivity in the brain among groups of subjects. Component models can be used to define subspace representations of functional connectivity that are more interpretable. It is, however, unclear which component model provides the optimal representation of functional networks for multi-subject fMRI datasets. A flexible cross-validation approach that assesses the ability of the models to predict voxel-wise covariance in new data, was proposed. This framework is used to compare a range of component models with varying degrees of flexibility in their representation of functional connectivity, evaluated on both simulated and experimental resting-state fMRI data. It was demonstrated that highly flexible subject-specific component subspaces, as well as very constrained average models, are poor predictors of whole-brain functional connectivity, whereas the best-generalizing models account for subject variability within a common spatial subspace. Within this set of models, spatial Independent Component Analysis (sICA) on concatenated data provides more interpretable brain patterns, whereas a consistent-covariance model that accounts for subject-specific network scaling (PARAFAC2) provides greater stability in functional connectivity relationships between components and their spatial representations. The proposed evaluation framework is a promising quantitative approach to evaluating component models, and reveals important differences between subspace models in terms of predictability, robustness, characterization of subject variability, and interpretability of the model parameters. Hum Brain Mapp, 2016.
Brain connectivity, Decomposition, Functional magnetic resonance imaging, Independent component analysis, Resting-state
Reducing the rate and duration of Re-ADMISsions among patients with unipolar disorder and bipolar disorder using smartphone-based monitoring and treatment - the RADMIS trials: Study protocol for two randomized controlled trials

Background: Unipolar and bipolar disorder combined account for nearly half of all morbidity and mortality due to mental and substance use disorders, and burden society with the highest health care costs of all psychiatric and neurological disorders. Among these, costs due to psychiatric hospitalization are a major burden. Smartphones comprise an innovative and unique platform for the monitoring and treatment of depression and mania. No prior trial has investigated whether the use of a smartphone-based system can prevent re-admission among patients discharged from hospital. The present RADMIS trials aim to investigate whether using a smartphone-based monitoring and treatment system, including an integrated clinical feedback loop, reduces the rate and duration of re-admissions more than standard treatment in unipolar disorder and bipolar disorder.

Methods: The RADMIS trials use a randomized controlled, single-blind, parallel-group design. Patients with unipolar disorder and patients with bipolar disorder are invited to participate in each trial when discharged from psychiatric hospitals in The Capital Region of Denmark following an affective episode and randomized to either (1) a smartphone-based monitoring system including (a) an integrated feedback loop between patients and clinicians and (b) context-aware cognitive behavioral therapy (CBT) modules (intervention group) or (2) standard treatment (control group) for a 6-month trial period. The trial started in May 2017. The outcomes are (1) number and duration of re-admissions (primary), (2) severity of depressive and manic (only for patients with bipolar disorder) symptoms; psychosocial functioning; number of affective episodes (secondary), and (3) perceived stress, quality of life, self-rated depressive symptoms, self-rated manic symptoms (only for patients with bipolar disorder), recovery, empowerment, adherence to medication, wellbeing, ruminations, worrying, and satisfaction (tertiary). A total of 400 patients (200 patients with unipolar disorder and 200 patients with bipolar disorder) will be included in the RADMIS trials.

Discussion: If the smartphone-based monitoring system proves effective in reducing the rate and duration of readmissions, there will be a basis for using a system of this kind in the treatment of unipolar and bipolar disorder in general and on a larger scale.
Rethinking Hearing Aid Fitting by Learning From Behavioral Patterns

The recent introduction of Internet connected hearing instruments offers a paradigm shift in hearing instrument fitting. Potentially this makes it possible for devices to adapt their settings to a changing context, inferred from user interactions. In a pilot study we enabled hearing instrument users to remotely enhance auditory focus and attenuate background noise to improve speech intelligibility. N=5, participants changed program settings and adjusted volume on their hearing instruments using their smartphones. We found that individual behavioral patterns affected the usage of the devices. A significant difference between program usage, and weekdays versus weekends, were found. Users not only changed programs to modify aspects of directionality and noise reduction, but also continuously adjusted the volume. Rethinking hearing instruments as devices that adaptively learn behavioral patterns based on user interaction, might provide a degree of personalization that has not been feasible due to lack of audiological resources.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Center for Health Technology, Eriksholm Research Centre, Oticon A/S
Authors: Johansen, B. (Intern), Petersen, M. K. (Ekstern), Pontoppidan, N. H. (Ekstern), Sandholm, P. (Ekstern), Larsen, J. E. (Intern)
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Risk for affective disorders is associated with greater prefrontal gray matter volumes: A prospective longitudinal study

Background: Major depression and bipolar disorders aggregates in families and are linked with a wide range of neurobiological abnormalities including cortical gray matter (GM) alterations. Prospective studies of individuals at familial risk may expose the neural mechanisms underlying risk transmission. Methods: We used voxel based morphometry to investigate changes in regional GM brain volume, over a seven-year period, in 37 initially healthy individuals having a mono- or di-zygotic twin diagnosed with major depression or bipolar disorder (high-risk group; mean age 41.6 yrs.) as compared to 36 individuals with no history of affective disorders in the index twin and first-degree relatives (low-risk group; mean age 38.5 yrs.). Results: Groups did not differ in regional GM volume changes over time. However, independent of time, high-risk twins had significantly greater GM volumes in bilateral dorsal anterior cingulate, inferior frontal gyrus and temporoparietal regions as compared to low-risk twins. Further, individuals who developed an affective disorder at follow-up (n=12), had relatively the largest GM volumes, both at baseline and follow-up, in the right dorsal anterior cingulate cortex and right inferior frontal cortex compared to high- and low-risk twins who remained well at follow-up. Conclusion: This pattern of apparently stable greater regional GM volume may constitute a neural marker of an increased risk for developing an affective disorder in individuals at familial risk.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Macoveanu, J. (Ekstern), Baaré, W. (Ekstern), Madsen, K. H. (Intern), Kessing, L. V. (Ekstern), Siebner, H. R. (Ekstern), Vinberg, M. (Ekstern)
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Scalable group level probabilistic sparse factor analysis

Many data-driven approaches exist to extract neural representations of functional magnetic resonance imaging (fMRI) data, but most of them lack a proper probabilistic formulation. We propose a scalable group level probabilistic sparse factor analysis (psFA) allowing spatially sparse maps, component pruning using automatic relevance determination (ARD) and subject specific heteroscedastic spatial noise modeling. For task-based and resting state fMRI, we show that the sparsity constraint gives rise to components similar to those obtained by group independent component analysis. The noise modeling shows that noise is reduced in areas typically associated with activation by the experimental design. The psFA model identifies sparse components and the probabilistic setting provides a natural way to handle parameter uncertainties. The variational Bayesian framework easily extends to more complex noise models than the presently considered.

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Authors: Hinrich, J. L. (Intern), Nielsen, S. F. V. (Intern), Riis, N. A. B. (Intern), Eriksen, C. (Ekstern), Frasig, J. (Ekstern), Kristensen, M. D. F. (Ekstern), Schmidt, M. N. (Intern), Madsen, K. H. (Intern), Mørup, M. (Intern)
Scholia and scientometrics with Wikidata

Scholia is a tool to handle scientific bibliographic information through Wikidata. The Scholia Web service creates on-the-fly scholarly profiles for researchers, organizations, journals, publishers, individual scholarly works, and for research topics. To collect the data, it queries the SPARQL-based Wikidata Query Service. Among several display formats available in Scholia are lists of publications for individual researchers and organizations, publications per year, employment timelines, as well as coauthor and topic networks and citation graphs. The Python package implementing the Web service is also able to format Wikidata bibliographic entries for use in LaTeX/BIBTeX. Apart from detailing Scholia, we describe how Wikidata has been used for bibliographic information and we also provide some scientometric statistics on this information.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, EvoMRI Communications, Maastricht University
Authors: Nielsen, F. Å. (Intern), Mietchen, D. (Ekstern), Willighagen, E. (Ekstern)
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Second-Order Assortative Mixing in Social Networks

In a social network, the number of links of a node, or node degree, is often assumed as a proxy for the node’s importance or prominence within the network. It is known that social networks exhibit the (first-order) assortative mixing, i.e. if two nodes are connected, they tend to have similar node degrees, suggesting that people tend to mix with those of comparable prominence. In this paper, we report the second-order assortative mixing in social networks. If two nodes are connected, we measure the degree correlation between their most prominent neighbours, rather than between the two nodes themselves. We observe very strong second-order assortative mixing in social networks, often significantly stronger than the first-order assortative mixing. This suggests that if two people interact in a social network, then the importance of the most prominent person each knows is very likely to be the same. This is also true if we measure the average prominence of neighbours of the two people. This property is weaker or negative in non-social networks. We investigate a number of possible explanations for this property. However, none of them was found to provide an adequate explanation. We therefore conclude that second-order assortative mixing is a new property of social networks.

Semi-Supervised Generation with Cluster-aware Generative Models

Deep generative models trained with large amounts of unlabelled data have proven to be powerful within the domain of unsupervised learning. Many real life data sets contain a small amount of labelled data points, that are typically disregarded when training generative models. We propose the Cluster-aware Generative Model, that uses unlabelled information to infer a latent representation that models the natural clustering of the data, and additional labelled data points to refine this clustering. The generative performances of the model significantly improve when labelled information
is exploited, obtaining a log-likelihood of −79.38 nats on permutation invariant MNIST, while also achieving competitive semi-supervised classification accuracies. The model can also be trained fully unsupervised, and still improve the log-likelihood performance with respect to related methods.

**SensibleSleep: A Bayesian Model for Learning Sleep Patterns from Smartphone Events**

We propose a Bayesian model for extracting sleep patterns from smartphone events. Our method is able to identify individuals’ daily sleep periods and their evolution over time, and provides an estimation of the probability of sleep and wake transitions. The model is fitted to more than 400 participants from two different datasets, and we verify the results against ground truth from dedicated armband sleep trackers. We show that the model is able to produce reliable sleep estimates with an accuracy of 0.89, both at the individual and at the collective level. Moreover the Bayesian model is able to quantify uncertainty and encode prior knowledge about sleep patterns. Compared with existing smartphone-based systems, our method requires only screen on/off events, and is therefore much less intrusive in terms of privacy and more battery-efficient.
Separable explanations of neural network decisions

Deep Taylor Decomposition is a method used to explain neural network decisions. When applying this method to non-dominant classifications, the resulting explanation does not reflect important features for the chosen classification. We propose that this is caused by the dense layers and propose a method to alleviate the effect by applying regularization. We assess the result by measuring the quality of the resulting explanations objectively and subjectively.
**Sequence Classification Using Third-Order Moments**

Model-based classification of sequence data using a set of hidden Markov models is a well-known technique. The involved score function, which is often based on the class-conditional likelihood, can, however, be computationally demanding, especially for long data sequences. Inspired by recent theoretical advances in spectral learning of hidden Markov models, we propose a score function based on third-order moments. In particular, we propose to use the Kullback-Leibler divergence between theoretical and empirical third-order moments for classification of sequence data with discrete observations. The proposed method provides lower computational complexity at classification time than the usual likelihood-based methods. In order to demonstrate the properties of the proposed method, we perform classification of both simulated data and empirical data from a human activity recognition study.

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Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 1.107 SNIP 1.143 CiteScore 2.5  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 0.964 SNIP 1.133 CiteScore 2.52  
Web of Science (2014): Indexed yes  
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Scopus rating (2013): SJR 0.827 SNIP 1.009 CiteScore 2.39  
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BFI (2012): BFI-level 2  
Scopus rating (2012): SJR 0.853 SNIP 1.36 CiteScore 2.48  
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BFI (2011): BFI-level 2  
Scopus rating (2011): SJR 1.312 SNIP 1.385 CiteScore 2.59  
ISI indexed (2011): ISI indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 1.459 SNIP 1.68  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 1.283 SNIP 1.656  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 1.486 SNIP 1.674  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.633 SNIP 2.117
Sparse Probabilistic Parallel Factor Analysis for the Modeling of PET and Task-fMRI Data

Modern datasets are often multiway in nature and can contain patterns common to a mode of the data (e.g. space, time, and subjects). Multiway decomposition such as parallel factor analysis (PARAFAC) take into account the intrinsic structure of the data, and sparse versions of these methods improve interpretability of the results. Here we propose a variational Bayesian parallel factor analysis (VB-PARAFAC) model and an extension with sparse priors (SP-PARAFAC). Notably, our formulation admits time and subject specific noise modeling as well as subject specific offsets (i.e., mean values). We confirmed the validity of the models through simulation and performed exploratory analysis of positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) data. Although more constrained, the proposed models performed similarly to more flexible models in approximating the PET data, which supports its robustness against noise. For fMRI, both models correctly identified task-related components, but were not able to segregate overlapping activations.

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Authors: Beliveau, V. (Ekstern), Papoutsakis, G. (Ekstern), Hinrich, J. L. (Intern), Mørup, M. (Intern)
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Bipolar disorder is an often disabling mental illness with a lifetime prevalence of 1%-2%, a high risk of recurrence of manic and depressive episodes, a lifelong elevated risk of suicide and a substantial heritability. The course of illness is frequently characterised by progressive shortening of interepisode intervals with each recurrence and increasing cognitive dysfunction in a subset of individuals with this condition. Clinically, diagnostic boundaries between bipolar disorder and other psychiatric disorders such as unipolar depression are unclear although pharmacological and psychological treatment strategies differ substantially. Patients with bipolar disorder are often misdiagnosed and the mean delay between onset and diagnosis is 5-10 years. Although the risk of relapse of depression and mania is high it is for most patients impossible to predict and consequently prevent upcoming episodes in an individual tailored way. The identification of objective biomarkers can both inform bipolar disorder diagnosis and provide biological targets for the development of new and personalised treatments. Accurate diagnosis of bipolar disorder in its early stages could help prevent the long-term detrimental effects of the illness.

The present Bipolar Illness Onset study aims to identify (1) a composite blood-based biomarker, (2) a composite electronic smartphone-based biomarker and (3) a neurocognitive and neuroimaging-based signature for bipolar disorder. The study will include 300 patients with newly diagnosed/first-episode bipolar disorder, 200 of their healthy siblings or offspring and 100 healthy individuals without a family history of affective disorder. All participants will be followed longitudinally with repeated blood samples and other biological tissues, self-monitored and automatically generated smartphone data, neuropsychological tests and a subset of the cohort with neuroimaging during a 5 to 10-year study period. The study has been approved by the Local Ethical Committee (H-7-2014-007) and the data agency, Capital Region of Copenhagen (RHP-2015-023), and the findings will be widely disseminated at international conferences and meetings including conferences for the International Society for Bipolar Disorders and the World Federation of Societies for Biological Psychiatry and in scientific peer-reviewed papers. NCT02888262.
The circle equation over finite fields

Interesting patterns in the geometry of a plane algebraic curve $C$ can be observed when the defining polynomial equation is solved over the family of finite fields. In this paper, we examine the case of $C$ the classical unit circle defined by the circle equation $x^2 + y^2 = 1$. As a main result, we establish a concise formula for the number of solutions to the circle equation over an arbitrary finite field. We also provide criteria for the existence of diagonal solutions to the circle equation. Finally, we give a precise description of how the number of solutions to the circle equation over a prime field grows as a function of the prime.

General information
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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy resources, services and control, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Aabrandt, A. (Intern), Hansen, V. L. (Intern)
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Scopus rating (2015): CiteScore 0.66 SNIP 0.655 SJR 0.285
Scopus rating (2014): CiteScore 0.53 SNIP 0.837 SJR 0.327
Scopus rating (2013): CiteScore 0.39 SNIP 0.712 SJR 0.442
Scopus rating (2012): CiteScore 0.41 SNIP 0.867 SJR 0.264
Scopus rating (2011): CiteScore 0.34 SNIP 0.485 SJR 0.249
Scopus rating (2010): SNIP 0.762 SJR 0.342
Scopus rating (2009): SNIP 0.627 SJR 0.332
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Scopus rating (2005): SNIP 0.712 SJR 0.4
Scopus rating (2004): SNIP 0.649 SJR 0.23
Scopus rating (2003): SNIP 0.711 SJR 0.408
Scopus rating (2002): SNIP 0.439 SJR 0.246
Scopus rating (2001): SNIP 0.414 SJR 0.2
Scopus rating (2000): SNIP 0.595 SJR 0.18
Scopus rating (1999): SNIP 0.725 SJR 0.185
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The GO-ACTIWE randomized controlled trial - An interdisciplinary study designed to investigate the health effects of active commuting and leisure time physical activity

Regular physical activity is efficacious for improving metabolic health in overweight and obese individuals, yet, many adults lead sedentary lives. Most exercise interventions have targeted leisure time, but physical activity also takes place in other domains of everyday life. Active commuting represents a promising alternative to increase physical activity, but it has yet to be established whether active commuting conveys health benefits on par with leisure time physical activity (LTPA).

A 6-month randomized controlled trial was designed to investigate the effects of increased physical activity in transport (bicycling) or leisure time domains (moderate or vigorous intensity endurance exercise). We included 188 overweight and class 1 obese sedentary women and men (20-45 years) of which 130 were randomized to either sedentary controls (n=18),
active commuting (n=35) or moderate (n=39) or vigorous (n=38) intensity LTPA. At baseline and after 3 and 6 months, participants underwent a rigorous 3-day biomedical test regimen followed by free-living measurements. In a sub-sample, physical activity level and energy expenditure were monitored by means of personal assistive technology and the doubly labeled water technique. Additionally, the delivery, reception and routinization of the exercise regimens were investigated by ethnological fieldwork. One year after termination of the intervention, participants will be invited for a follow-up visit to investigate sustained health effects and continuous physical activity adherence. By combining biomedical, technological and humanistic approaches, we aim to understand the health benefits of physical activity in different domains of everyday life, as well as how to improve adherence to physical activity.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark, University of Copenhagen
Authors: Rosenkilde, M. (Ekstern), Petersen, M. B. (Forskerdatabase), Gram, A. S. (Ekstern), Quist, J. S. (Ekstern), Winther, J. (Forskerdatabase), Kamronn, S. D. (Intern), Milling, D. H. (Ekstern), Larsen, J. E. (Intern), Jespersen, A. P. (Forskerdatabase), Stallknecht, B. (Ekstern)
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BFI (2016): BFI-level 1
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BFI (2015): BFI-level 1
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Scopus rating (2014): SJR 1.222 SNIP 0.871 CiteScore 1.88
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.216 SNIP 0.997 CiteScore 1.93
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Scopus rating (2012): SJR 1.18 SNIP 0.954 CiteScore 1.74
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Scopus rating (2011): SJR 1.146 SNIP 1.036 CiteScore 1.72
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.214 SNIP 0.852
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Scopus rating (2009): SJR 1.24 SNIP 0.936
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Scopus rating (2008): SJR 1.178 SNIP 0.906
Scopus rating (2007): SJR 1.423 SNIP 1.178
Scopus rating (2006): SJR 0.756 SNIP 1.178
Scopus rating (2005): SNIP 1.301
Scopus rating (2004): SNIP 1.434
Scopus rating (2003): SNIP 1.285
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The missing link: Predicting connectomes from noisy and partially observed tract tracing data

Our understanding of the wiring map of the brain, known as the connectome, has increased greatly in the last decade, mostly due to technological advancements in neuroimaging techniques and improvements in computational tools to interpret the vast amount of available data. Despite this, with the exception of the C. elegans roundworm, no definitive connectome has been established for any species. In order to obtain this, tracer studies are particularly appealing, as these have proven highly reliable. The downside of tract tracing is that it is costly to perform, and can only be applied ex vivo. In this paper, we suggest that instead of probing all possible connections, hitherto unknown connections may be predicted from the data that is already available. Our approach uses a 'latent space model' that embeds the connectivity in an abstract physical space. Regions that are close in the latent space have a high chance of being connected, while regions far apart are most likely disconnected in the connectome. After learning the latent embedding from the connections that we did observe, the latent space allows us to predict connections that have not been probed previously. We apply the methodology to two connectivity data sets of the macaque, where we demonstrate that the latent space model is successful in predicting unobserved connectivity, outperforming two baselines and an alternative model in nearly all cases. Furthermore, we show how the latent spatial embedding may be used to integrate multimodal observations (i.e. anterograde and retrograde tracers) for the mouse neocortex. Finally, our probabilistic approach enables us to make explicit which connections are easy to predict and which prove difficult, allowing for informed follow-up studies.
The role of gender in social network organization

The digital traces we leave behind when engaging with the modern world offer an interesting lens through which we study behavioral patterns as expression of gender. Although gender differentiation has been observed in a number of settings, the majority of studies focus on a single data stream in isolation. Here we use a dataset of high resolution data collected using mobile phones, as well as detailed questionnaires, to study gender differences in a large cohort. We consider mobility behavior and individual personality traits among a group of more than 800 university students. We also investigate interactions among them expressed via person-to-person contacts, interactions on online social networks, and telecommunication. Thus, we are able to study the differences between male and female behavior captured through a multitude of channels for a single cohort. We find that while the two genders are similar in a number of aspects, there are robust deviations that include multiple facets of social interactions, suggesting the existence of inherent behavioral differences. Finally, we quantify how aspects of an individual’s characteristics and social behavior reveals their gender by posing it as a classification problem. We ask: How well can we distinguish between male and female study participants based on behavior alone? Which behavioral features are most predictive?
Transformations Based on Continuous Piecewise-Affine Velocity Fields

We propose novel finite-dimensional spaces of well-behaved transformations. The latter are obtained by (fast and highly-accurate) integration of continuous piecewise-affine velocity fields. The proposed method is simple yet highly expressive, effortlessly handles optional constraints (e.g., volume preservation and/or boundary conditions), and supports convenient modeling choices such as smoothing priors and coarse-to-fine analysis. Importantly, the proposed approach, partly due to its rapid likelihood evaluations and partly due to its other properties, facilitates tractable inference over rich transformation spaces, including using Markov-Chain Monte-Carlo methods. Its applications include, but are not limited to: monotonic regression (more generally, optimization over monotonic functions); modeling cumulative distribution functions or histograms; time-warping; image warping; image registration; real-time diffeomorphic image editing; data augmentation for image classifiers. Our GPU-based code is publicly available.
Continuous piecewise-affine velocity fields, Diffeomorphisms, Tessellations, Priors, Spatial transformations
Two subgroups of antipsychotic-naive, first-episode schizophrenia patients identified with a Gaussian mixture model on cognition and electrophysiology

Deficits in information processing and cognition are among the most robust findings in schizophrenia patients. Previous efforts to translate group-level deficits into clinically relevant and individualized information have, however, been non-successful, which is possibly explained by biologically different disease subgroups. We applied machine learning algorithms on measures of electrophysiology and cognition to identify potential subgroups of schizophrenia. Next, we explored subgroup differences regarding treatment response. Sixty-six antipsychotic-naive first-episode schizophrenia patients and sixty-five healthy controls underwent extensive electrophysiological and neurocognitive test batteries. Patients were assessed on the Positive and Negative Syndrome Scale (PANSS) before and after 6 weeks of monotherapy with the relatively selective D2 receptor antagonist, amisulpride (280.3±159mg per day). A reduced principal component space based on 19 electrophysiological variables and 26 cognitive variables was used as input for a Gaussian mixture model to identify subgroups of patients. With support vector machines, we explored the relation between PANSS subscores and the identified subgroups. We identified two statistically distinct subgroups of patients. We found no significant baseline psychopathological differences between these subgroups, but the effect of treatment in the groups was predicted with an accuracy of 74.3% (P=0.003). In conclusion, electrophysiology and cognition data may be used to classify subgroups of schizophrenia. The two distinct subgroups, which we identified, were psychopathologically inseparable before treatment, yet their response to dopaminergic blockade was predicted with significant accuracy. This proof of principle encourages further endeavors to apply data-driven, multivariate and multimodal models to facilitate progress from symptom-based psychiatry toward individualized treatment regimens.
Unraveling fermentation data – a Novozymes case study
Industrial fermentation processes are monitored using a variety of sensors. Typically, measurements are taken throughout the entire production process. Production may be carried out under supervision of different operators (operator variation), on different sites (global variation), in different buildings and/or in different tanks (local variation). However, up to now processes are mainly controlled according to traditional recipes and experience

General information
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Authors: Baum, A. (Intern), Vermue, L. (Intern), Moiseyenko, R. (Intern), Jørgensen, T. M. (Intern), Devantier, R. (Ekstern)
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Using data- and network science to reveal iterations and phase-transitions in the design process
Understanding the role of iterations is a prevalent topic in both design research and design practice. Furthermore, the increasing amount of data produced and stored by companies leaves traces and enables the application of data science to learn from past design processes. In this article, we analyse a documentlog to show the temporal evolution of a real design process of a power plant by using exploratory data analysis and network analysis. We show how the iterative nature of the design process is reflected in archival data and how one might re-construct the design process, involving iterations between many parties, including the client, external consultants, suppliers, and designers. We also show how people use different representations during the design process and how this is associated with a design phase transition in the process. Finally, we relate our findings with the literature on iterations and discuss implications for research and practice with application to project management and process modelling.

General information
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Organisations: Copenhagen Center for Health Technology, Department of Management Engineering, Engineering Systems, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Piccolo, S. (Intern), Jørgensen, S. L. (Intern), Maier, A. (Intern)
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Using OR + AI to Predict the Optimal Production of Offshore Wind Parks: A Preliminary Study
In this paper we propose a new use of Machine Learning together with Mathematical Optimization. We investigate the question of whether a machine, trained on a large number of optimized solutions, can accurately estimate the value of the optimized solution for new instances. We focus on instances of a specific problem, namely, the offshore wind farm layout optimization problem. In this problem an offshore site is given, together with the wind statistics and the characteristics of the turbines that need to be built. The optimization wants to determine the optimal allocation of turbines to maximize the park power production, taking the mutual interference between turbines into account. Mixed Integer Programming models and other state-of-the-art optimization techniques, have been developed to solve this problem. Starting with a dataset of 2000+ optimized layouts found by the optimizer, we used supervised learning to estimate the production of new wind parks. Our results show that Machine Learning is able to well estimate the optimal value of offshore wind farm layout problems.
Whole-brain functional connectivity predicted by indirect structural connections

Modern functional and diffusion magnetic resonance imaging (fMRI and dMRI) provide data from which macro-scale networks of functional and structural whole brain connectivity can be estimated. Although networks derived from these two modalities describe different properties of the human brain, they emerge from the same underlying brain organization, and functional communication is presumably mediated by structural connections. In this paper, we assess the structure-function relationship by evaluating how well functional connectivity can be predicted from structural graphs. Using high-resolution whole brain networks generated with varying density, we contrast the performance of several non-parametric link predictors that measure structural communication flow. While functional connectivity is not well predicted directly by structural connections, we show that superior predictions can be achieved by taking indirect structural pathways into account. In particular, we find that the length of the shortest structural path between brain regions is a good predictor of functional connectivity in sparse networks (density less than one percent), and that this improvement comes from integrating indirect pathways comprising up to three steps. Our results support the existence of important indirect relationships between structure and function, extending beyond the immediate direct structural connections that are typically investigated.
Why Do We Fall into Sync with Others? Interpersonal Synchronization and the Brain's Optimization Principle

Spontaneous interpersonal synchronization of rhythmic behavior such as gait or clapping is a ubiquitous phenomenon in human interactions, and is potentially important for social relationships and action understanding. Although several authors have suggested a role of the mirror neuron system in interpersonal coupling, the underlying brain mechanisms are not well understood. Here we argue that more general theories of neural computations, namely predictive coding and the Free Energy Principle, could explain interpersonal coordination dynamics. Each brain minimizes coding costs by reducing the mismatch between the representations of observed and own motor behavior. Continuous mutual prediction and alignment result in an overall minimization of free energy, thus forming a stable attractor state.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Colorado Boulder, University of Wisconsin-Madison
Authors: Koban, L. (Ekstern), Ramamoorthy, A. (Ekstern), Konvalinka, I. (Intern)
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Scopus rating (2016): CiteScore 2.6 SNIP 0.882 SJR 1.405
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BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.23 SNIP 0.976 SJR 1.898
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Scopus rating (2013): CiteScore 3.47 SNIP 1.011 SJR 1.834
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.73 SNIP 0.884 SJR 1.94
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.91 SNIP 0.985 SJR 1.927
BFI (2010): BFI-level 1
Scopus rating (2010): SNIP 1.063 SJR 2.231
BFI (2009): BFI-level 1
Scopus rating (2009): SNIP 1.151 SJR 1.933
BFI (2008): BFI-level 1
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Working Memory Modulation of Frontoparietal Network Connectivity in First-Episode Schizophrenia

Working memory (WM) impairment is regarded as a core aspect of schizophrenia. However, the neural mechanisms behind this cognitive deficit remain unclear. The connectivity of a frontoparietal network is known to be important for subserving WM. Using functional magnetic resonance imaging, the current study investigated whether WM-dependent modulation of effective connectivity in this network is affected in a group of first-episode schizophrenia (FES) patients...
compared with similarly performing healthy participants during a verbal n-back task. Dynamic causal modeling (DCM) of
the coupling between regions (left inferior frontal gyrus (IFG), left inferior parietal lobe (IPL), and primary visual area)
identified in a psychophysiological interaction (PPI) analysis was performed to characterize effective connectivity during
the n-back task. The PPI analysis revealed that the connectivity between the left IFG and left IPL was modulated by WM
and that this modulation was reduced in FES patients. The subsequent DCM analysis confirmed this modulation by WM
and found evidence that FES patients had reduced forward connectivity from IPL to IFG. These findings provide evidence
for impaired WM modulation of frontoparietal effective connectivity in the early phase of schizophrenia, even with intact
WM performance, suggesting a failure of context-sensitive coupling in the schizophrenic brain.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Central South University,
University College London
Authors: Nielsen, J. D. (Intern), Madsen, K. H. (Intern), Wang, Z. (Ekstern), Liu, Z. (Ekstern), Friston, K. J. (Ekstern),
Zhou, Y. (Ekstern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.5 SJR 4.103 SNIP 1.614
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.929 SNIP 1.872 CiteScore 6.68
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.887 SNIP 1.994 CiteScore 6.86
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 5.386 SNIP 1.899 CiteScore 7.26
ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 5.077 SNIP 1.916 CiteScore 7.28
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Scopus rating (2011): SJR 5.187 SNIP 1.893 CiteScore 7.2
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 5.074 SNIP 1.843
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 5.158 SNIP 1.896
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 4.992 SNIP 1.762
Scopus rating (2005): SJR 4.464 SNIP 1.773
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 4.128 SNIP 1.676
Aberrant neural signatures of decision-making: Pathological gamblers display cortico-striatal hypersensitivity to extreme gambles

Pathological gambling is an addictive disorder characterized by an irresistible urge to gamble despite severe consequences. One of the hallmarks of pathological gambling is maladaptive and highly risky decision-making, which has been linked to dysregulation of reward-related brain regions such as the ventral striatum. However, previous studies have produced contradictory results regarding the implication of this network, revealing either hypo- or hypersensitivity to monetary gains and losses. One possible explanation is that the gambling brain might be misrepresenting the benefits and costs when weighting the potential outcomes, and not the gains and losses per se. To address this issue, we investigated whether pathological gambling is associated with abnormal brain activity during decisions that weight the utility of possible gains against possible losses. Pathological gamblers and healthy human subjects underwent functional magnetic resonance imaging while they accepted or rejected mixed gain/loss gambles with fifty-fifty chances of winning or losing. Contrary to healthy individuals, gamblers showed a U-shaped response profile reflecting hypersensitivity to the most appetitive and most aversive bets in an executive cortico-striatal network including the dorsolateral prefrontal cortex and caudate nucleus. This network is concerned with the evaluation of action-outcome contingencies, monitoring recent actions and anticipating their consequences. The dysregulation of this specific network, especially for extreme bets with large potentials consequences, offers a novel understanding of the neural basis of pathological gambling in terms of deficient associations between gambling actions and their financial impact.

General information
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Authors: Gelskov, S. V. (Ekstern), Madsen, K. H. (Intern), Ramsøy, T. Z. (Ekstern), Siebner, H. R. (Ekstern)
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.967 SNIP 1.759
Web of Science (2016): Indexed yes
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Accurate continuous geographic assignment from low- to high-density SNP data

Motivation: Large-scale genotype datasets can help tracking the dispersal patterns of epidemiological outbreaks and predicting the geographic origins of individuals. This shows direct applications in forensics for profiling both victims and criminals, and in wildlife management, where poaching hotspot areas can be located. Such approaches, however, require
fast and accurate geographical assignment methods.

**Results:** We introduce a novel statistical method for geopositioning individuals of unknown origin from genotypes. Our method is based on a geostatistical model trained with a dataset of georeferenced genotypes. Statistical inference under this model can be implemented within the theoretical framework of Integrated Nested Laplace Approximation (INLA), which represents one of the major recent breakthroughs in statistics, devoid of Monte Carlo simulations. We compare the performance of our method and SPA in a simulation framework. We highlight the accuracy and limits of continuous spatial assignment methods at various scales by analyzing genotype datasets from a diversity of species, including Florida scrub jay birds Aphelocoma coerulescens, Arabidopsis thaliana and humans, representing 41 to 197,146 SNPs. Our method appears to be best tailored for the analysis of medium-size datasets (a few tens of thousands of loci), such as reduced-representation sequencing data that become increasingly available in ecology.

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- **Organisations:** Department of Applied Mathematics and Computer Science, Cognitive Systems, Natural History Museum of Denmark, Technical University of Denmark, University of Copenhagen
- **Authors:** Guillot, G. (Intern), Jónsson, H. (Ekstern), Hinge, A. (Ekstern), Manchih, N. (Ekstern), Orlando, L. (Ekstern)
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  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): CiteScore 5.5
  - Web of Science (2014): Indexed yes
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  - BFI (2012): BFI-level 2
  - Scopus rating (2012): CiteScore 6.73
  - ISI indexed (2012): ISI indexed yes
  - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 2
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  - Web of Science (2011): Indexed yes
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  - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 2
  - Web of Science (2009): Indexed yes
  - BFI (2008): BFI-level 2
  - Web of Science (2008): Indexed yes
  - Web of Science (2007): Indexed yes
Active vibration-based SHM system: demonstration on an operating Vestas V27 wind turbine

This study presents a system that is able to detect defects like cracks, leading/trailing edge opening or delamination of at least 15 cm size, remotely, without stopping the wind turbine. The system is vibration-based: mechanical energy is artificially introduced by means of an electromechanical actuator, whose plunger periodically hits the blade. The induced vibrations propagate along the blade and are picked up by an array of accelerometers. The vibrations in mid-range frequencies are utilized: this range is above the frequencies excited by blade-wind interaction, ensuring a good signal-to-noise ratio. At the same time, the corresponding wavelength is short enough to deliver required damage detection resolution and long enough to be able to propagate the entire blade length.

The paper demonstrates the system on a 225 kW Vestas V27 wind turbine. One blade of the wind turbine was equipped with the system and a 3.5 month monitoring campaign was conducted while the turbine was operating normally. During the campaign, a defect – a trailing edge opening – was artificially introduced into the blade and its size was gradually increased from the original 15 cm to 45 cm.

Using an unsupervised learning algorithm, we were able to detect even the smallest amount of damage while the wind turbine was operating under different weather conditions. The paper provides the detailed information about the instrumentation and the measurement campaign and explains the damage detection algorithm.

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Algebraic Varieties and System Design
Design and analysis of networks have many applications in the engineering sciences. This dissertation seeks to contribute to the methods used in the analysis of networks with a view towards assisting decision making processes. Networks are initially considered as objects in the category of graphs and later as objects in the category of hypergraphs. The connection with the category of simplicial pairs become apparent when the topology is analyzed using homological algebra. A topological ranking is developed that measures the ability of the network to stay path-connected. Combined with the analysis of cover ideals of hypergraphs, the topological ranking demonstrates the non-trivial decisions that needs to be considered in system design. All the methods developed here have an underlying common structure, namely that
they all appear at solution sets for systems of polynomials. These solution sets are called algebraic varieties.

A locally adaptive normal distribution
The multivariate normal density is a monotonic function of the distance to the mean, and its ellipsoidal shape is due to the underlying Euclidean metric. We suggest to replace this metric with a locally adaptive, smoothly changing (Riemannian) metric that favors regions of high local density. The resulting locally adaptive normal distribution (LAND) is a generalization of the normal distribution to the "manifold" setting, where data is assumed to lie near a potentially low-dimensional manifold embedded in RD. The LAND is parametric, depending only on a mean and a covariance, and is the maximum entropy distribution under the given metric. The underlying metric is, however, non-parametric. We develop a maximum likelihood algorithm to infer the distribution parameters that relies on a combination of gradient descent and Monte Carlo integration. We further extend the LAND to mixture models, and provide the corresponding EM algorithm. We demonstrate the efficiency of the LAND to fit non-trivial probability distributions over both synthetic data, and EEG measurements of human sleep.

A locally adaptive normal distribution
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A Note on Powers in Finite Fields
The study of solutions to polynomial equations over finite fields has a long history in mathematics and is an interesting area of contemporary research. In recent years the subject has found important applications in the modelling of problems from applied mathematical fields such as signal analysis, system theory, coding theory and cryptology. In this connection it is of interest to know criteria for the existence of squares and other powers in arbitrary finite fields. Making good use of polynomial division in polynomial rings over finite fields, we have examined a classical criterion of Euler for squares in odd prime fields, giving it a formulation which is apt for generalization to arbitrary finite fields and powers. Our proof uses algebra rather than classical number theory, which makes it convenient when presenting basic methods of applied algebra in the classroom.

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Archetypal Analysis for Modeling Multisubject fMRI Data

Functional magnetic resonance imaging (fMRI) is widely used to measure brain function during various cognitive states. However, it remains a challenge to obtain low-rank models of functional networks in fMRI that have interpretable latent features and generalize across groups of subjects, due to significant intersubject variability in the signal structure and noise. Group-level modeling is typically performed using component decompositions such as independent component analysis (ICA), which represent data as a linear combination of latent brain patterns, or using clustering models, where data are assumed to be generated by a set of 'prototype' time series. Archetypal analysis (AA) provides a promising alternative, combining the advantages of component-model flexibility with highly interpretable latent 'archetypes' (similar to cluster-model prototypes). To date, AA has not been applied to group-level fMRI; a major limitation is that it does not generalize to multi-subject datasets, which may have significant variations in blood oxygenation-level-dependent signal and heteroscedastic noise. We develop multi-subject AA (MS-AA), which accounts for group-level data by assuming that archetypal temporal profiles have a common latent generator across subjects, ensuring that the temporal components are derived from a consistent set of brain regions. In addition, the model accounts for noise heteroscedasticity by modeling subject- and voxel-specific noise variance. This provides a novel approach to group-level modeling and an alternative to preexisting methods that account for inter-subject variability by extracting individual maps as a postprocessing step (e.g., dual-regression ICA), or assuming spatial dependency of maps across subjects (e.g., independent vector analysis). MS-AA shows robust performance when modelling archetypes for a motor task experiment. The procedure extracts a 'seed map' across subjects, used to provide brain parcellations with subject-specific temporal profiles. Our approach thus decomposes multisubject fMRI data into distinct interpretable component archetypes that may help to model both consistent group-level measures of fMRI data and individual variability.
Assessing Levels of Attention Using Low Cost Eye Tracking

The emergence of mobile eye trackers embedded in next generation smartphones or VR displays will make it possible to trace not only what objects we look at but also the level of attention in a given situation. Exploring whether we can quantify the engagement of a user interacting with a laptop, we apply mobile eye tracking in an in-depth study over 2 weeks with nearly 10,000 observations to assess pupil size changes, related to attentional aspects of alertness, orientation and conflict resolution. Visually presenting conflicting cues and targets we hypothesize that it’s feasible to measure the allocated effort when responding to confusing stimuli. Although such experiments are normally carried out in a lab, we have initial indications that we are able to differentiate between sustained alertness and complex decision making even with low cost eye tracking “in the wild”. From a quantified self perspective of individual behavioural adaptation, the correlations between the pupil size and the task dependent reaction time and error rates may longer term provide a foundation for modifying smartphone content and interaction to the users perceived level of attention.

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Assessment of Rotationally-Invariant Clustering Using Streamlet Tractography

We present a novel visualisation-based strategy for the assessment of a recently proposed clustering technique for raw DWI volumes which derives rotationally-invariant metrics to classify voxels. The validity of the division of all brain tissue voxels into such classes was assessed using the recently developed streamlets visualisation technique, which aims to represent brain fibres by collections of many short streamlines. Under the assumption that streamlines seeded in a cluster should stay within it, we were able to assess how well perceptual tracing could occur across the boundaries of the clusters.

Assessment of Rotationally-Invariant Clustering Using Streamlet Tractography

We consider the problem of solving TAP mean field equations by iteration for Ising models with coupling matrices that are drawn at random from general invariant ensembles. We develop an analysis of iterative algorithms using a dynamical functional approach that in the thermodynamic limit yields an effective dynamics of a single variable trajectory. Our main novel contribution is the expression for the implicit memory term of the dynamics for general invariant ensembles. By subtracting these terms, that depend on magnetizations at previous time steps, the implicit memory terms cancel making the iteration dependent on a Gaussian distributed field only. The TAP magnetizations are stable fixed points if a de Almeida–Thouless stability criterion is fulfilled. We illustrate our method explicitly for coupling matrices drawn from the random orthogonal ensemble.

A theory of solving TAP equations for Ising models with general invariant random matrices

We consider the problem of solving TAP mean field equations by iteration for Ising models with coupling matrices that are drawn at random from general invariant ensembles. We develop an analysis of iterative algorithms using a dynamical functional approach that in the thermodynamic limit yields an effective dynamics of a single variable trajectory. Our main novel contribution is the expression for the implicit memory term of the dynamics for general invariant ensembles. By subtracting these terms, that depend on magnetizations at previous time steps, the implicit memory terms cancel making the iteration dependent on a Gaussian distributed field only. The TAP magnetizations are stable fixed points if a de Almeida–Thouless stability criterion is fulfilled. We illustrate our method explicitly for coupling matrices drawn from the random orthogonal ensemble.
Ising models, TAP equations, Dynamical functional theory, Iterative convergent algorithms, Random matrices, Free probability

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Autoencoding beyond pixels using a learned similarity metric

We present an autoencoder that leverages learned representations to better measure similarities in data space. By combining a variational autoencoder (VAE) with a generative adversarial network (GAN) we can use learned feature representations in the GAN discriminator as basis for the VAE reconstruction objective. Thereby, we replace element-wise errors with feature-wise errors to better capture the data distribution while offering invariance towards e.g. translation. We apply our method to images of faces and show that it outperforms VAEs with element-wise similarity measures in terms of visual fidelity. Moreover, we show that the method learns an embedding in which high-level abstract visual features (e.g. wearing glasses) can be modified using simple arithmetic.

Auxiliary Deep Generative Models

Deep generative models parameterized by neural networks have recently achieved state-of-the-art performance in unsupervised and semi-supervised learning. We extend deep generative models with auxiliary variables which improves the variational approximation. The auxiliary variables leave the generative model unchanged but make the variational distribution more expressive. Inspired by the structure of the auxiliary variable we also propose a model with two stochastic layers and skip connections. Our findings suggest that more expressive and properly specified deep generative models converge faster with better results. We show state-of-the-art performance within semi-supervised learning on MNIST (0.96%), SVHN (16.61%) and NORB (9.40%) datasets.
Bayesian latent feature modeling for modeling bipartite networks with overlapping groups

Bi-partite networks are commonly modelled using latent class or latent feature models. Whereas the existing latent class models admit marginalization of parameters specifying the strength of interaction between groups, existing latent feature models do not admit analytical marginalization of the parameters accounting for the interaction strength within the feature representation. We propose a new binary latent feature model that admits analytical marginalization of interaction strengths such that model inference reduces to assigning nodes to latent features. We propose a constraint inspired by the notion of community structure such that the edge density within groups is higher than between groups. Our model further assumes that entities can have different propensities of generating links in one of the modes. The proposed framework is contrasted on both synthetic and real bi-partite networks to the infinite relational model and the infinite Bernoulli mixture model. We find that the model provides a new latent feature representation of structure while in link-prediction performing close to existing models. Our current extension of the notion of communities and collapsed inference to binary latent feature representations in bipartite networks provides a new framework for accounting for structure in bi-partite networks using binary latent feature representations providing interpretable representations that well characterize structure as quantified by link prediction.

Bayesian leave-one-out cross-validation approximations for Gaussian latent variable models

The future predictive performance of a Bayesian model can be estimated using Bayesian cross-validation. In this article, we consider Gaussian latent variable models where the integration over the latent values is approximated using the Laplace method or expectation propagation (EP). We study the properties of several Bayesian leave-one-out (LOO) cross-validation approximations that in most cases can be computed with a small additional cost after forming the posterior approximation given the full data. Our main objective is to assess the accuracy of the approximative LOO cross-validation estimators. That is, for each method (Laplace and EP) we compare the approximate fast computation with the exact brute force LOO computation. Secondarily, we evaluate the accuracy of the Laplace and EP approximations themselves against a ground truth established through extensive Markov chain Monte Carlo simulation. Our empirical results show that the approach based upon a Gaussian approximation to the LOO marginal distribution (the so-called cavity distribution) gives the most accurate and reliable results among the fast methods.
BloodSpot: a database of gene expression profiles and transcriptional programs for healthy and malignant haematopoiesis

Research on human and murine haematopoiesis has resulted in a vast number of gene-expression data sets that can potentially answer questions regarding normal and aberrant blood formation. To researchers and clinicians with limited bioinformatics experience, these data have remained available, yet largely inaccessible. Current databases provide information about gene-expression but fail to answer key questions regarding co-regulation, genetic programs or effect on patient survival. To address these shortcomings, we present BloodSpot (www.bloodspot.eu), which includes and greatly extends our previously released database HemaExplorer, a database of gene expression profiles from FACS sorted healthy and malignant haematopoietic cells. A revised interactive interface simultaneously provides a plot of gene expression along with a Kaplan–Meier analysis and a hierarchical tree depicting the relationship between different cell types in the database. The database now includes 23 high-quality curated data sets relevant to normal and malignant blood formation and, in addition, we have assembled and built a unique integrated data set, BloodPool. Bloodpool contains more than 2000 samples assembled from six independent studies on acute myeloid leukemia. Furthermore, we have devised a robust sample integration procedure that allows for sensitive comparison of user-supplied patient samples in a well-defined haematopoietic cellular space.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Technical University of Denmark
Authors: Bagger, F. O. (Intern), Sasivarevic, D. (Ekstern), Hadi Sohi, S. (Intern), Laursen, L. G. (Ekstern), Pundhir, S. (Ekstern), Sønderby, C. K. (Ekstern), Winther, O. (Intern), Rapin, N. (Intern), Porse, B. T. (Ekstern)
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This paper describes an aptamer-based optomagnetic biosensor for detection of a small molecule based on target binding-induced inhibition of magnetic nanoparticle (MNP) clustering. For the detection of a target small molecule, two mutually exclusive binding reactions (aptamer-target binding and aptamer-DNA linker hybridization) are designed. An aptamer specific to the target and a DNA linker complementary to a part of the aptamer sequence are immobilized onto separate MNPs. Hybridization of the DNA linker and the aptamer induces formation of MNP clusters. The target-to-aptamer binding on MNPs prior to the addition of linker-functionalized MNPs significantly hinders the hybridization reaction, thus reducing the degree of MNP clustering. The clustering state, which is thus related to the target concentration, is then quantitatively determined by an optomagnetic readout technique that provides the hydrodynamic size distribution of MNPs and their clusters. A commercial Blu-ray optical pickup unit is used for optical signal acquisition, which enables the establishment of a low-cost and miniaturized biosensing platform. Experimental results show that the degree of MNP clustering correlates well with the concentration of a target small molecule, adenosine triphosphate (ATP) in this work, in the range between 10µM and 10mM. This successful proof-of-concept indicates that our optomagnetic aptasensor can be further developed as a low-cost biosensing platform for detection of small molecule biomarkers in an out-of-lab setting.
Brain-computer interfacing under distraction: an evaluation study

Objective. While motor-imagery based brain-computer interfaces (BCIs) have been studied over many years by now, most of these studies have taken place in controlled lab settings. Bringing BCI technology into everyday life is still one of the main challenges in this field of research. Approach. This paper systematically investigates BCI performance under 6 types of distractions that mimic out-of-lab environments. Main results. We report results of 16 participants and show that the performance of the standard common spatial patterns (CSP) + regularized linear discriminant analysis classification pipeline drops significantly in this ‘simulated’ out-of-lab setting. We then investigate three methods for improving the performance: (1) artifact removal, (2) ensemble classification, and (3) a 2-step classification approach. While artifact removal does not enhance the BCI performance significantly, both ensemble classification and the 2-step classification combined with CSP significantly improve the performance compared to the standard procedure. Significance. Systematically analyzing out-of-lab scenarios is crucial when bringing BCI into everyday life. Algorithms must be adapted to overcome nonstationary environments in order to tackle real-world challenges.
Completely random measures for modelling block-structured sparse networks

Many statistical methods for network data parameterize the edge-probability by attributing latent traits to the vertices such as block structure and assume exchangeability in the sense of the Aldous-Hoover representation theorem. Empirical studies of networks indicate that many real-world networks have a power-law distribution of the vertices which in turn implies the number of edges scale slower than quadratically in the number of vertices. These assumptions are fundamentally irreconcilable as the Aldous-Hoover theorem implies quadratic scaling of the number of edges. Recently Caron and Fox [2014] proposed the use of a different notion of exchangeability due to Kallenberg [2006] and obtained a network model which admits power-law behaviour while retaining desirable statistical properties, however this model does not capture latent vertex traits such as block-structure. In this work we re-introduce the use of block-structure for network models obeying allenberg's notion of exchangeability and thereby obtain a model which admits the inference of block-structure and edge inhomogeneity. We derive a simple expression for the likelihood and an efficient sampling method. The obtained model is not significantly more difficult to implement than existing approaches to block-modelling and performs well on real network datasets.

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Data driven estimation of imputation error - a strategy for imputation with a reject option
Missing data is a common problem in many research fields and is a challenge that always needs careful considerations. One approach is to impute the missing values, i.e., replace missing values with estimates. When imputation is applied, it is typically applied to all records with missing values indiscriminately. We note that the effects of imputation can be strongly dependent on what is missing. To help make decisions about which records should be imputed, we propose to use a machine learning approach to estimate the imputation error for each case with missing data. The method is thought to be a practical approach to help users using imputation after the informed choice to impute the missing data has been made. To do this all patterns of missing values are simulated in all complete cases, enabling calculation of the "true error" in each of these new cases. The error is then estimated for each case with missing values by weighing the "true errors" by similarity. The method can also be used to test the performance of different imputation methods. A universal numerical threshold of acceptable error cannot be set since this will differ according to the data, research question, and analysis
method. The effect of threshold can be estimated using the complete cases. The user can set an a priori relevant threshold for what is acceptable or use cross validation with the final analysis to choose the threshold. The choice can be presented along with argumentation for the choice rather than holding to conventions that might not be warranted in the specific dataset.

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- Web of Science (2015): Indexed yes
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- Scopus rating (2014): SJR 1.559 SNIP 1.148 CiteScore 3.54
- Web of Science (2014): Indexed yes
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- Web of Science (2008): Indexed yes
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Data-driven forward model inference for EEG brain imaging
Electroencephalography (EEG) is a flexible and accessible tool with excellent temporal resolution but with a spatial resolution hampered by volume conduction. Reconstruction of the cortical sources of measured EEG activity partly alleviates this problem and effectively turns EEG into a brain imaging device. The quality of the source reconstruction depends on the forward model which details head geometry and conductivities of different head compartments. These person-specific factors are complex to determine, requiring detailed knowledge of the subject’s anatomy and physiology. In this proof-of-concept study, we show that, even when anatomical knowledge is unavailable, a suitable forward model can be estimated directly from the EEG. We propose a data-driven approach that provides a low-dimensional parametrization of head geometry and compartment conductivities, built using a corpus of forward models. Combined with only a recorded EEG signal, we are able to estimate both the brain sources and a person-specific forward model by optimizing this parametrization. Our work demonstrates that personalized EEG brain imaging is possible, even when the head geometry and conductivities are unknown.
Decomposition and classification of electroencephalography data

This thesis is about linear and multi-linear analyses of electroencephalography (EEG) data and classification of estimated EEG sources. One contribution consists of an automatic classification method for independent components (ICs) of EEG data and a freely available implementation as an EEGLab plug-in, "IC Classification into Multiple Artefact Classes" (IC_MARC). Four artefact classes (blinks, heart beats, lateral eye movements, and muscle contractions), a neural class, and a mixed class (representing none or a mix of the other classes) were considered. We showed that classification is possible between subjects within studies over all classes. When generalising across studies a high classification rate of neural vs. non-neural ICs was retained but the multi-class performance dropped. In another study, we used IC_MARC to compare the ability to separate artefactual from neural sources of six linear decomposition methods. This study showed that high-pass filtering data at high cut-off frequencies improved artefact removal performances in an Event-Related Desynchronisation setting, providing similar performances of the three included Independent Component Analysis variants. IC_MARC was also used to inspect effects of artefacts on motor imagery based Brain-Computer Interfaces (BCIs) in two studies, where removing artefactual ICs had little performance impact. Finally, we investigated multi-linear classification on single trials of EEG data, proposing a rigorous optimisation approach. To enforce orthonormality of projection matrices, objective functions quantifying class discrimination were optimised on a cross-product of Stiefel (orthonormal matrix) manifolds. Supervised feature extraction outperformed unsupervised methods, but the choice of
supervised method mattered less. We suggested completions of methods to include both PARAFAC and Tucker structures. The two structures provided similar performances, making the more interpretable PARAFAC models appealing.

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Design of Cognitive Interfaces for Personal Informatics Feedback
The emergence of embedded low-cost sensors in mobile devices allows us to capture unprecedented data about human behavior. Hence personal informatics systems are becoming an integrated part of our everyday life: Capturing various aspects from our health, work-life, to economic balance, and utility consumption. All of which are aimed to provide knowledge of oneself, on which we can reflect. Many personal informatics systems are characterized by mainly focusing on collecting and analyzing data, rather than translating the data into meaningful feedback. This dissertation presents challenges related to personal informatics systems, and propose an approach to design cognitive interfaces, which considers both users' motivations, needs, and goals.

In this thesis I propose a new personal informatics framework, the feedback loop, which incorporates lean agile design principles. Including hierarchical modeling of goals, activities, and tasks to create minimal viable products. While considering how micro-interactions based on an understanding of data, couples with user needs and the context they appear in, can contribute to creating cognitive interfaces. Designing cognitive interfaces requires a focus on translating data into meaningful feedback, which the users can reflect on in order to gain insights. Thus I present tools such as personalized baselines and thresholds to enable reflection, while creating personalized goals, scenarios, trade-offs in order to provide actionable feedback, which can help users to adjust their behavior. Although feedback can be provided in many different ways, it basically consists of audio, visual, and haptic components, which combined may reinforce each other to support the underlying interaction.

The papers included in this thesis cover selected parts of the feedback loop. For instance, examining emotional responses to pleasant and unpleasant media content from brain activity, reveals the large amount of data and extensive analysis required to apply this to future personal informatics systems. In addition we analyse challenges related to temporal aspects of the feedback loop, when users attempt to self-regulate their brain activity based on a real-time feedback. This leads to identification of underlying audio, visual and haptic feedback components, which combined may support the underlying interaction within personal informatics. And with the emerging availability of sensor packed wearable devices, haptic feedback may become an inherent part of personal informatics systems, which could enhance the interaction based visual feedback.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Jensen, C. B. F. (Intern), Larsen, J. E. (Intern), Petersen, M. K. (Intern)
Number of pages: 160
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Series: DTU Compute PHD-2015
Number: 383
ISSN: 0909-3192
Development and implementation of a PV performance monitoring system based on inverter measurements

Performance monitoring and fault detection systems have become necessary for decreasing operation and maintenance cost in large photovoltaic (PV) plants, as well for maximizing plant yield and lifetime. We expect a similar development for residential and commercial PV system applications, where currently the cost of the performance monitoring hardware and implementation is high. Therefore, we present the practical development and implementation of a PV performance monitoring system for residential and commercial PV applications, where the cost of the monitoring hardware is lowered, by using the inverter's own monitoring and communication capabilities. We also aim to lower the implementation cost, by using a simple, but accurate performance monitoring approach, and show the practical issues that can arise when implementing such a system.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Applied Electronics, Aalborg University
Authors: Spataru, S. (Ekstern), Gavriluta, A. F. (Ekstern), Maaløe, L. (Intern), Sera, D. (Ekstern), Winther, O. (Intern)
Pages: 1-7
Publication date: 2016

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ISBN (Print): 9781509007370
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Photovoltaic (PV) power systems, performance monitoring, Photovoltaic (PV) inverter
DOIs: 10.1109/ECCE.2016.7855039
Source: FindIt
Source-ID: 2303858284
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Development and validation of a colorimetric sensor array for fish spoilage monitoring

Given the need for non-destructive methods and sensors for food spoilage monitoring, we have evaluated sixteen chemosensitive compounds incorporated in an array for colorimetric detection of typical spoilage compounds (trimethylamine, dimethylamine, cadaverine, putrescine) and characterized their color changes in response to compounds present in fresh products (hexanal, 1-octane-3-ol) used as negative controls.

The colorimetric sensor array was used to follow fish spoilage over time at room temperature for up to 24 h as well as at 4 °C for 9 days. Additionally, fish decay was monitored using traditional assays measuring the quantity of thiobarbituric acid, total volatile basic nitrogen, changes in pH, O2 level, as well as following bacterial growth. We found a linear correlation between changes in pH, thiobarbituric acid content and the signal intensity recorded with the colorimetric array over time. During spoilage, the increase in signal intensity of the chemosensitive compounds showed a similar trend as the increase in microbial growth. We observed that the sensitivity of the chemosensitive compounds depends on the spoilage conditions (room temperature vs. 4 °C), highlighting the importance of the application of an array instead of single chemosensitive compounds when following complex changes during food spoilage.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Department of Applied Mathematics and Computer Science, Cognitive Systems, Bioanalytics, Surface Engineering, Benha University, University College Cork
Number of pages: 7
Pages: 346-352
Publication date: 2016
Forward Models can be Inferred from EEG Data

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Hansen, S. T. (Intern), Hauberg, S. (Intern), Hansen, L. K. (Intern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences

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Publication: Research - peer-review » Poster – Annual report year: 2016
Source-ID: 127113343

Fundamental structures of dynamic social networks

Social systems are in a constant state of flux, with dynamics spanning from minute-by-minute changes to patterns present on the timescale of years. Accurate models of social dynamics are important for understanding the spreading of influence or diseases, formation of friendships, and the productivity of teams. Although there has been much progress on understanding complex networks over the past decade, little is known about the regularities governing the microdynamics of social networks. Here, we explore the dynamic social network of a densely-connected population of ~1,000 individuals and their interactions in the network of real-world person-to-person proximity measured via Bluetooth, as well as their telecommunication networks, online social media contacts, geolocation, and demographic data. These high-resolution data allow us to observe social groups directly, rendering community detection unnecessary. Starting from 5-min time slices, we uncover dynamic social structures expressed on multiple timescales. On the hourly timescale, we find that gatherings are fluid, with members coming and going, but organized via a stable core of individuals. Each core represents a social context. Cores exhibit a pattern of recurring meetings across weeks and months, each with varying degrees of regularity. Taken together, these findings provide a powerful simplification of the social network, where cores represent fundamental structures expressed with strong temporal and spatial regularity. Using this framework, we explore the complex interplay between social and geospatial behavior, documenting how the formation of cores is preceded by coordination behavior in the communication networks and demonstrating that social behavior can be predicted with high precision.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Center for Health Technology, University of Copenhagen, Massachusetts Institute of Technology
Authors: Sekara, V. (Intern), Stopczynski, A. (Intern), Jørgensen, S. L. (Intern)
Pages: 9977-9982
How to Train Deep Variational Autoencoders and Probabilistic Ladder Networks

Variational autoencoders are a powerful framework for unsupervised learning. However, previous work has been restricted to shallow models with one or two layers of fully factorized stochastic latent variables, limiting the flexibility of the latent representation. We propose three advances in training algorithms of variational autoencoders, for the first time allowing to train deep models of up to five stochastic layers, (1) using a structure similar to the Ladder network as the inference model, (2) warm-up period to support stochastic units staying active in early training, and (3) use of batch normalization. Using these improvements we show state-of-the-art log-likelihood results for generative modeling on several benchmark datasets.

Independent vector analysis for capturing common components in fMRI group analysis

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

Human mobility patterns are inherently complex. In terms of understanding these patterns, the process of converting raw data into series of stop-locations and transitions is an important first step which greatly reduces the volume of data, thus simplifying the subsequent analyses. Previous research into the mobility of individuals has focused on inferring ‘stop locations’ (places of stationarity) from GPS or CDR data, or on detection of state (static/active). In this paper we bridge the gap between the two approaches: we introduce methods for detecting both mobility state and stop-locations. In addition, our methods are based exclusively on WiFi data. We study two months of WiFi data collected every two minutes by a smartphone, and infer stop-locations in the form of labelled time-intervals. For this purpose, we investigate two algorithms, both of which scale to large datasets: a greedy approach to select the most important routers and one which uses a density-based clustering algorithm to detect router fingerprints. We validate our results using participants’ GPS data as well as ground truth data collected during a two month period.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark
Authors: Wind, D. K. (Intern), Sapiezynski, P. (Intern), Furman, M. A. (Ekstern), Jørgensen, S. L. (Intern)
Number of pages: 15
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 1.164 SNIP 1.111
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.11 SJR 1.236 SNIP 1.101
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.427 SNIP 1.136 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.559 SNIP 1.148 CiteScore 3.54
Ladder Variational Autoencoder

Variational autoencoders are powerful models for unsupervised learning. However deep models with several layers of dependent stochastic variables are difficult to train which limits the improvements obtained using these highly expressive models. We propose a new inference model, the Ladder Variational Autoencoder, that recursively corrects the generative distribution by a data dependent approximate likelihood in a process resembling the recently proposed Ladder Network. We show that this model provides state of the art predictive log-likelihood and tighter log-likelihood lower bound compared to the purely bottom-up inference in layered Variational Autoencoders and other generative models. We provide a detailed analysis of the learned hierarchical latent representation and show that our new inference model is qualitatively different and utilizes a deeper more distributed hierarchy of latent variables. Finally, we observe that batch normalization and deterministic warm-up (gradually turning on the KL-term) are crucial for training variational models with many stochastic layers.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Center for Health Technology, University of Copenhagen, Aalto University
Authors: Sønderby, C. K. (Ekstern), Raiko, T. (Ekstern), Maaløe, L. (Intern), Sønderby, S. K. (Ekstern), Winther, O. (Intern)
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Host publication information
Title of host publication: Advances in Neural Information Processing Systems 29 (NIPS 2016)
BFI conference series: Neural Information Processing Systems (5000199)
**Literature, Geolocation and Wikidata**

Littar was the second-prize winning entry in an app competition. It implemented a system for visualizing places mentioned in individual literary works. Wikidata acted as the backend for the system. Here I describe the Littar system and also some of the issues I encountered while developing the system: How locations and literature can be related, what types of location-literature relations are possible within Wiki-data, what limitations there are and what questions we may ask once we have enough data in Wikidata.

**Measure of Node Similarity in Multilayer Networks**

The weight of links in a network is often related to the similarity of the nodes. Here, we introduce a simple tunable measure for analysing the similarity of nodes across different link weights. In particular, we use the measure to analyze homophily in a group of 659 freshman students at a large university. Our analysis is based on data obtained using smartphones equipped with custom data collection software, complemented by questionnaire-based data. The network of social contacts is represented as a weighted multilayer network constructed from different channels of telecommunication as well as data on face-to-face contacts. We find that even strongly connected individuals are not more similar with respect to basic personality traits than randomly chosen pairs of individuals. In contrast, several socio-demographic variables have an significant degree of similarity. We further observe that similarity might be present in one layer of the multilayer network and simultaneously be absent in the other layers. For a variable such as gender, our measure reveals a transition from similarity between nodes connected with links of relatively low weight to dis-similarity for the nodes connected by the strongest links. We finally analyze the overlap between layers in the network for different levels of acquaintanceships.
Measuring Motion-Induced B0-Fluctuations in the Brain Using Field Probes

Purpose: Fluctuations of the background magnetic field (B0) due to body and breathing motion can lead to significant artifacts in brain imaging at ultrahigh field. Corrections based on real-time sensing using external field probes show great potential. This study evaluates different aspects of field interpolation from these probes into the brain which is implicit in such methods. Measurements and simulations were performed to quantify how well B0-fluctuations in the brain due to body and breathing motion are reflected in external field probe measurements. Methods: Field probe measurements were compared with scanner acquired B0-maps from experiments with breathing and shoulder movements. A realistic simulation of B0-fluctuations caused by breathing was performed, and used for testing different sets of field probe positions. Results: The B0-fluctuations were well reflected in the field probe measurements in the shoulder experiments, while the breathing experiments showed only moderate correspondence. The simulations showed the importance of the probe positions, and that performing full 3rd order corrections based on 16 field probes is not recommended. Conclusion: Methods for quantitative assessment of the field interpolation problem were developed and demonstrated. Field corrections based on external field measurements show great potential, although potential pitfalls were identified.

General information
State: Published
Organisations: Center for Magnetic Resonance, Department of Electrical Engineering, Center for Hyperpolarization in Magnetic Resonance, Department of Applied Mathematics and Computer Science, Cognitive Systems, Leiden University Medical Center, Leiden University, University Medical Centre Utrecht
Authors: Andersen, M. (Intern), Hanson, L. G. (Intern), Madsen, K. H. (Intern), Wezel, J. (Ekstern), Boer, V. (Ekstern), van der Velden, T. (Ekstern), van Osch, M. J. (Ekstern), Klomp, D. (Ekstern), Webb, A. G. (Ekstern), Versluis, M. J. (Ekstern)
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BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.411 SJR 1.89
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.52 SJR 1.945 SNIP 1.451
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.329 SNIP 1.481 CiteScore 3.54
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.015 SNIP 1.382 CiteScore 3.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.039 SNIP 1.433 CiteScore 3.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.158 SNIP 1.553 CiteScore 3.61
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.16 SNIP 1.461 CiteScore 3.45
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.356 SNIP 1.606
Neural Markers of Responsiveness to the Environment in Human Sleep

Sleep is characterized by a loss of behavioral responsiveness. However, recent research has shown that the sleeping brain is not completely disconnected from its environment. How neural activity constrains the ability to process sensory information while asleep is yet unclear. Here, we instructed human volunteers to classify words with lateralized hand responses while falling asleep. Using an electroencephalographic (EEG) marker of motor preparation, we show how responsiveness is modulated across sleep. These modulations are tracked using classic event-related potential analyses complemented by Lempel-Ziv complexity (LZc), a measure shown to track arousal in sleep and anesthesia. Neural activity related to the semantic content of stimuli was conserved in light non-rapid eye movement (NREM) sleep. However, these processes were suppressed in deep NREM sleep and, importantly, also in REM sleep, despite the recovery of wake-like neural activity in the latter. In NREM sleep, sensory activations were counterbalanced by evoked down states, which, when present, blocked further processing of external information. In addition, responsiveness markers correlated positively with baseline complexity, which could be related to modulation in sleep depth. In REM sleep, however, this relationship was reversed. We therefore propose that, in REM sleep, endogenously generated processes compete with the processing of external input. Sleep can thus be seen as a self-regulated process in which external information can be processed in lighter stages but suppressed in deeper stages. Last, our results suggest drastically different gating mechanisms in NREM and REM sleep.
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 1.593 SJR 4.466
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.96 SJR 4.849 SNIP 1.617
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 5.042 SNIP 1.694 CiteScore 6.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 5.305 SNIP 1.761 CiteScore 6.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 5.742 SNIP 1.863 CiteScore 7.22
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 5.743 SNIP 1.963 CiteScore 7.6
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 5.864 SNIP 1.905 CiteScore 7.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 6.15 SNIP 1.867
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 6.678 SNIP 1.89
Scopus rating (2007): SJR 6.112 SNIP 1.925
Scopus rating (2006): SJR 5.951 SNIP 1.921
Scopus rating (2005): SJR 5.92 SNIP 1.982
Scopus rating (2004): SJR 5.995 SNIP 1.973
Scopus rating (2003): SJR 6.027 SNIP 2.053
Scopus rating (2002): SJR 6.05 SNIP 2
Scopus rating (2001): SJR 5.802 SNIP 2.058
Scopus rating (1999): SJR 7.05 SNIP 2.237
Original language: English
Complexity, EEG, NREM, REM, Sensory processing, Sleep
Electronic versions:
Neural_Markers_of_Responsiveness_to_the_Environment_in_Human_Sleep.pdf
DOIs:
Source: FindIt
Source-ID: 2305857213
Publication: Research - peer-review › Journal article – Annual report year: 2016
New frontiers of quantified self 2: Going beyond numbers
While the Quantified Self (QS) community is described in terms of “self-knowledge through numbers” people are increasingly demanding value and meaning. In this workshop we aim at refocusing the QS debate on the value of data for providing new services.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Turin, University of Sydney, University of Glasgow, Technische Universitat Berlin, University of Washington, Madeira Interactive Technologies Institute
Authors: Rapp, A. (Ekstern), Cena, F. (Ekstern), Kay, J. (Ekstern), Kummerfeld, B. (Ekstern), Hopfgartner, F. (Ekstern), Plumbaum, T. (Ekstern), Larsen, J. E. (Intern), Epstein, D. A. (Ekstern), Gouveia, R. (Ekstern)
Pages: 506-509
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ISBN (Electronic): 9781450344623
BFI conference series: ACM International Joint Conference on Pervasive and Ubiquitous Computing (5000606)
Main Research Area: Technical/natural sciences
Personal Informatics, Quantified Self, Self-Tracking, Selfmonitoring, Wearable Technologies
DOIs: 10.1145/2968219.2968331
Source: Scopus
Source-ID: 84991056309
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Obtaining Data on Hearing Experience Through Self-tracking
This position paper argues that self-tracking data can enrich a pre-fitting process of hearing aids. It is argued that hearing loss consist of three parts. Tonal sensitivity, signal to-noise-sensitivity, and cognitive capabilities which can be assessed by using smartphones. Combining this with contextual data and subjective data (perceived fatigue for example), could generated a hearing profile for the end user. This could be used for continuous fitting based on user feedback of the hearing instruments at a later point in time.

We suggest, that pre-fitting and a continuous process could create a paradigm shift empowering and transforming the user into an essential part of the solution, through increased awareness and inclusion. The end result could be a potentially better fitting, and a better hearing experience for the individual.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Johansen, B. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern)
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Main Research Area: Technical/natural sciences
Hearing Aids, Cognition, Working Memory Capacity, Quanti ed self, non-clinical setu, Personal Informatics, Wearable, Smartphone
DOIs: 10.1145/2968219.2968327
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Source-ID: 127803436
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
Open Problem: Kernel methods on manifolds and metric spaces: What is the probability of a positive definite geodesic exponential kernel?

Radial kernels are well-suited for machine learning over general geodesic metric spaces, where pairwise distances are often the only computable quantity available. We have recently shown that geodesic exponential kernels are only positive definite for all bandwidths when the input space has strong linear properties. This negative result hints that radial kernels are perhaps not suitable over geodesic metric spaces after all. Here, however, we present evidence that large intervals of bandwidths exist where geodesic exponential kernels have high probability of being positive definite over finite datasets, while still having significant predictive power. From this we formulate conjectures on the probability of a positive definite kernel matrix for a finite random sample, depending on the geometry of the data space and the spread of the sample.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Feragen, A. (Ekstern), Hauberg, S. (Intern)
Number of pages: 4
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Volume: 49
Series: JMLR: Workshop and Conference Proceedings
ISSN: 1938-7228
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Main Research Area: Technical/natural sciences
Kernel Methods, Geodesic Metric Spaces, Geodesic Exponential Kernel, Positive Definiteness, Curvature, Bandwidth Selection
Electronic versions: feragen16.pdf
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Optimization of neural networks for time-domain simulation of mooring lines
When using artificial neural networks in methods for dynamic analysis of slender structures, the computational effort associated with time-domain response simulation may be reduced drastically compared to classic solution strategies. This article demonstrates that the network structure of an artificial neural network, which has been trained to simulate forces in a mooring line of a floating offshore platform, can be optimized and reduced by different optimization procedures. The procedures both detect and prune the least salient network weights successively, and besides trimming the network, they also can be used to rank the importance of the various network inputs. The dynamic response of slender marine structures often depends on several external load components, and by applying the optimization procedures to a trained artificial neural network, it is possible to classify the external force components with respect to importance and subsequently determine which of them may be ignored in the analysis. The performance of the optimization procedures is illustrated by a numerical example, which shows that, in particular, the most simple procedures are able to remove more than half of the network weights in an artificial neural network without significant loss of simulation accuracy.

General information
State: Published
Organisations: Department of Mechanical Engineering, Department of Applied Mathematics and Computer Science, Cognitive Systems, Solid Mechanics, DNV GL A/S
Authors: Christiansen, N. H. (Intern), Voie, P. E. T. (Ekstern), Winther, O. (Intern), Høgsberg, J. B. (Intern)
Pages: 434-443
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Main Research Area: Technical/natural sciences

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Oxytocin improves synchronisation in leader-follower interaction

The neuropeptide oxytocin has been shown to affect social interaction. Meanwhile, the underlying mechanism remains highly debated. Using an interpersonal finger-tapping paradigm, we investigated whether oxytocin affects the ability to synchronise with and adapt to the behaviour of others. Dyads received either oxytocin or a non-active placebo, intranasally. We show that in conditions where one dyad-member was tapping to another unresponsive dyad-member - i.e. one was following another who was leading/self-pacing - dyads given oxytocin were more synchronised than dyads given placebo. However, there was no effect when following a regular metronome or when both tappers were mutually adapting to each other. Furthermore, relative to their self-paced tapping partners, oxytocin followers were less variable than placebo followers. Our data suggests that oxytocin improves synchronisation to an unresponsive partner's behaviour through a reduction in tapping-variability. Hence, oxytocin may facilitate social interaction by enhancing sensorimotor predictions supporting interpersonal synchronisation. The study thus provides novel perspectives on how neurobiological processes relate to socio-psychological behaviour and contributes to the growing evidence that synchronisation and prediction are central to social cognition.
Predicting the emotions expressed in music

With the ever-growing popularity and availability of digital music through streaming services and digital download, making sense of the millions of songs, is ever more pertinent. However the traditional approach of creating music systems has treated songs like items in a store, like books and movies. However music is special, having origins in a number of evolutionary adaptations. The fundamental needs and goals of a users use of music, was investigated to create the next generation of music systems. People listen to music to regulate their mood and emotions was found to be the most important fundamental reason. (Mis)matching peoples mood with the emotions expressed in music was found to be an essential underlying mechanism, people use to regulate their emotions. This formed the basis and overall goal of the thesis, to investigate how to create a predictive model of emotions expressed in music. To use in the next generation of
music systems.

The thesis was divided into three main topics involved in creating a predictive model 1) Elicitation of emotion, 2) Audio representation and 3) Modelling framework, associating the emotion and audio representation, allowing to predict the emotions expressed in music.

The traditional approach of quantifying musical stimuli on the valence and arousal representation of emotions using continuous or likert scales was questioned. An outline of a number of bias and the so-called confidence effect when using bipolar scales led to the use of relative scales in the form of pairwise comparisons. One issue with pairwise comparisons is the scaling, this was solved using an active learning approach through a Gaussian Process model.

Traditional audio representation disregards all temporal information in audio features used for modelling the emotions expressed in music. Therefore a probabilistic feature representation framework was introduced enabling both temporal and non-temporal aspects to be coded in discrete and continuous features. Generative models are estimated for each feature time-series and used in a discriminative setting using the Probability Product Kernel (PPK) allowing the use of this approach in any kernel machine.

To model the pairwise comparisons directly, a Generalized Linear Model, a kernel extension and a Gaussian Process model were used. These models can predict the ranking of songs on the valence and arousal dimensions directly. Furthermore use of the PPK allowed to find optimal combinations of both feature and feature representation using Multiple Kernel Learning.
Prospective motion correction for MRI using EEG-equipment
A new prospective motion correction technique is presented that is based on signals from gradient switching, in an EEG-cap with interconnected electrodes the subject wears during scanning. The method has no line-of-sight limitations as optical methods, requires no interleaved navigator modules or additional hardware for sites already doing EEG-fMRI. Instead a training scan is performed were signals recorded with the EEG-system are correlated with motion parameters estimated by image realignment. Initial results from application of the method in a phantom are promising.
Recovery from an acute relapse is associated with changes in motor resting-state connectivity in multiple sclerosis

Resting-state functional MRI (rs-fMRI) of the brain has been successfully used to identify altered functional connectivity in the motor network in multiple sclerosis (MS). In clinically stable patients with MS, we recently demonstrated increased coupling between the basal ganglia and the motor network. Accordingly, rs-fMRI in MS is particularly suited to investigate functional reorganisation of the motor network in the remission phase after a relapse because the resting-state connectivity pattern is not influenced by interindividual differences in motor ability and task performance. In this prospective rs-fMRI study, we mapped acute changes in resting-state motor connectivity in 12 patients with relapsing forms of MS presenting with an acute relapse involving an upper limb paresis. Previous functional MRI (fMRI) studies have shown that the activation of sensorimotor areas was stronger and more widespread in the brain of patients with MS compared to healthy controls and increased proportionally with the extent of MS-related brain damage. We therefore hypothesised that a motor relapse involving paresis of the upper limbs would trigger an acute compensatory increase in motor resting-state connectivity and that the compensatory increase in functional connectivity would decrease over the following days or weeks in proportion to the degree of clinical remission.
Resting-State Connectivity Predicts Levodopa-Induced Dyskinesias in Parkinson's Disease

Background: Levodopa-induced dyskinesias are a common side effect of dopaminergic therapy in PD, but their neural correlates remain poorly understood.

Objectives: This study examines whether dyskinesias are associated with abnormal dopaminergic modulation of resting-state cortico-striatal connectivity.

Methods: Twelve PD patients with peak-of-dose dyskinesias and 12 patients without dyskinesias were withdrawn from dopaminergic medication. All patients received a single dose of fast-acting soluble levodopa and then underwent resting-state functional magnetic resonance imaging before any dyskinesias emerged. Levodopa-induced modulation of cortico-striatal resting-state connectivity was assessed between the putamen and the following 3 cortical regions of interest: supplementary motor area, primary sensorimotor cortex, and right inferior frontal gyrus. These functional connectivity measures were entered into a linear support vector classifier to predict whether an individual patient would develop dyskinesias after levodopa intake. Linear regression analysis was applied to test which connectivity measures would predict dyskinesia severity.

Results: Dopaminergic modulation of resting-state connectivity between the putamen and primary sensorimotor cortex in the most affected hemisphere predicted whether patients would develop dyskinesias with a specificity of 100% and a sensitivity of 91% (P < .0001). Modulation of resting-state connectivity between the supplementary motor area and putamen predicted interindividual differences in dyskinesia severity (R² = 0.627, P = .004). Resting-state connectivity between the right inferior frontal gyrus and putamen neither predicted dyskinesia status nor dyskinesia severity.

Conclusions: The results corroborate the notion that altered dopaminergic modulation of cortico-striatal connectivity plays a key role in the pathophysiology of dyskinesias in PD.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital
Authors: Herz, D. M. (Ekstern), Haagensen, B. N. (Ekstern), Nielsen, S. H. (Ekstern), Madsen, K. H. (Intern), Løkkegaard, A. (Ekstern), Siebner, H. R. (Ekstern)
Pages: 521-529
Retrieving Radio News Broadcasts in Danish: Accuracy and Categorization of Unrecognized Words

Digital archives of radio news broadcasts can possibly be made searchable by combining speech recognition with information retrieval. We explore this possibility for the retrieval of news broadcasts in Danish. An average of 84% of the words in the broadcasts was recognized. Most of the unrecognized words were compounds, names, and other words that appear of value to retrieval. Thus, the set of words describing a broadcast has to be expanded to compensate for the recognition errors. We discuss doing this by exploiting the alternative matches from the speech recognizer and by extracting words from a related corpus.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Hertzum, M. (Ekstern), Lund, H. (Ekstern), Troelsgaard, R. (Intern)
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Scalable Robust Principal Component Analysis Using Grassmann Averages

In large datasets, manual data verification is impossible, and we must expect the number of outliers to increase with data size. While principal component analysis (PCA) can reduce data size, and scalable solutions exist, it is well-known that outliers can arbitrarily corrupt the results. Unfortunately, state-of-the-art approaches for robust PCA are not scalable. We note that in a zero-mean dataset, each observation spans a one-dimensional subspace, giving a point on the Grassmann manifold. We show that the average subspace corresponds to the leading principal component for Gaussian data. We provide a simple algorithm for computing this Grassmann Average (GA), and show that the subspace estimate is less sensitive to outliers than PCA for general distributions. Because averages can be efficiently computed, we immediately gain scalability. We exploit robust averaging to formulate the Robust Grassmann Average (RGA) as a form of robust PCA. The resulting Trimmed Grassmann Average (TGA) is appropriate for computer vision because it is robust to pixel outliers. The algorithm has linear computational complexity and minimal memory requirements. We demonstrate TGA for background modeling, video restoration, and shadow removal. We show scalability by performing robust PCA on the entire Star Wars IV movie; a task beyond any current method. Source code is available online.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Max Planck Institute for Intelligent Systems
Authors: Hauberg, S. (Intern), Feragen, A. (Ekstern), Enficiaud, R. (Ekstern), Black, M. J. (Ekstern)
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Scopus rating (2014): SJR 3.475 SNIP 7.634 CiteScore 11.05
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Scopus rating (2012): SJR 2.874 SNIP 8.948 CiteScore 10.09
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Scopus rating (2011): SJR 2.508 SNIP 7.15 CiteScore 8.89
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.634 SNIP 7.144
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Scopus rating (2006): SJR 2.815 SNIP 6.645
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Sequential neural models with stochastic layers
How can we efficiently propagate uncertainty in a latent state representation with recurrent neural networks? This paper introduces stochastic recurrent neural networks which glue a deterministic recurrent neural network and a state space model together to form a stochastic and sequential neural generative model. The clear separation of deterministic and stochastic layers allows a structured variational inference network to track the factorization of the model's posterior distribution. By retaining both the nonlinear recursive structure of a recurrent neural network and averaging over the uncertainty in a latent path, like a state space model, we improve the state of the art results on the Blizzard and TIMIT speech modeling data sets by a large margin, while achieving comparable performances to competing methods on polyphonic music modeling.

Spatial hearing with incongruent visual or auditory room cues
In day-to-day life, humans usually perceive the location of sound sources as outside their heads. This externalized auditory spatial perception can be reproduced through headphones by recreating the sound pressure generated by the source at the listener's eardrums. This requires the acoustical features of the recording environment and listener's anatomy to be recorded at the listener's ear canals. Although the resulting auditory images can be indistinguishable from real-world sources, their externalization may be less robust when the playback and recording environments differ. Here we tested whether a mismatch between playback and recording room reduces perceived distance, azimuthal direction, and compactness of the auditory image, and whether this is mostly due to incongruent auditory cues or to expectations generated from the visual impression of the room. Perceived distance ratings decreased significantly when collected in a more reverberant environment than the recording room, whereas azimuthal direction and compactness remained room independent. Moreover, modifying visual room-related cues had no effect on these three attributes, while incongruent auditory room-related cues between the recording and playback room did affect distance perception. Consequently, the external perception of virtual sounds depends on the degree of congruency between the acoustical features of the environment and the stimuli.
Spatio-temporal reconstruction of brain dynamics from EEG with a Markov prior

Electroencephalography (EEG) can capture brain dynamics in high temporal resolution. By projecting the scalp EEG signal back to its origin in the brain also high spatial resolution can be achieved. Source localized EEG therefore has potential to be a very powerful tool for understanding the functional dynamics of the brain. Solving the inverse problem of EEG is however highly ill-posed as there are many more potential locations of the EEG generators than EEG measurement points. Several well-known properties of brain dynamics can be exploited to alleviate this problem. More short ranging connections exist in the brain than long ranging, arguing for spatially focal sources. Additionally, recent work (Delorme et al., 2012) argues that EEG can be decomposed into components having sparse source distributions. On the temporal side both short and long term stationarity of brain activation are seen. We summarize these insights in an inverse solver, the so-called "Variational Garrote" (Kappen and Gómez, 2013). Using a Markov prior we can incorporate flexible degrees of temporal stationarity. Through spatial basis functions spatially smooth distributions are obtained. Sparsity of these are inherent to the Variational Garrote solver. We name our method the MarkoVG and demonstrate its ability to adapt to the temporal smoothness and spatial sparsity in simulated EEG data. Finally a benchmark EEG dataset is used to demonstrate MarkoVG's ability to recover non-stationary brain dynamics.
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Strategies of Legitimacy Through Social Media: The Networked Strategy

How can corporations develop legitimacy when coping with stakeholders who have multiple, often conflicting sustainable development (SD) agendas? We address this question by conducting an in-depth longitudinal case study of a corporation's stakeholder engagement in social media and propose the concept of a networked legitimacy strategy. With this strategy, legitimacy is gained through participation in non-hierarchical open platforms and the co-construction of agendas. We explore the organizational transition needed to yield this new legitimacy approach. We argue that, in this context, legitimacy gains may increase when firms are able to reduce the control over the engagements and relate non-hierarchically with their publics. We contribute to the extant literature on political corporate social responsibility and legitimacy by providing an understanding of a new context for engagement that reconfigures cultural, network, and power relations between the firm and their stakeholders in ways that challenge previous forms of legitimation.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Universidad Carlos III de Madrid, Copenhagen Business School
Authors: Castelló, I. (Ekstern), Etter, M. (Ekstern), Nielsen, F. Å. (Intern)
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Structural parcellation of the thalamus using shortest-path tractography

We demonstrate how structural parcellation can be implemented using shortest-path tractography, thereby addressing some of the shortcomings of the conventional approaches. In particular, our algorithm quantifies, via p-values, the confidence that a voxel in the parcellated region is connected to each cortical target region. Calculation of these statistical measures is derived from a rank-based test on the histogram of tract-based scores from all the shortest paths found between the source voxel and each voxel within the target region. Using data from the Human Connectome Project, we show that parcellation of the thalamus results in p-value maps that are spatially coherent across subjects. Comparing to the state-of-the-art parcellation of Behrens et al. [1], we observe some agreement, but the soft segmentation exhibits better stability for voxels connected to multiple target regions.

Supervised hub-detection for brain connectivity

A structural brain network consists of physical connections between brain regions. Brain network analysis aims to find features associated with a parameter of interest through supervised prediction models such as regression. Unsupervised preprocessing steps like clustering are often applied, but can smooth discriminative signals in the population, degrading predictive performance. We present a novel hub-detection optimized for supervised learning that both clusters network nodes based on population level variation in connectivity and also takes the learning problem into account. The found hubs are a low-dimensional representation of the network and are chosen based on predictive performance as features for a linear regression. We apply our method to the problem of finding age-related changes in structural connectivity. We compare our supervised hub-detection (SHD) to an unsupervised hub-detection and a linear regression using the original network connections as features. The results show that the SHD is able to retain regression performance, while still finding hubs that represent the underlying variation in the population. Although here we applied the SHD to brain networks, it can be applied to any network regression problem. Further development of the presented algorithm will be the extension to other predictive models such as classification or non-linear regression.
Surface-enhanced Raman spectroscopic study of DNA and 6-mercapto-1-hexanol interactions using large area mapping

The emergence of 2D SERS substrates with large areas of hot spots has enabled data to be gathered at large scale. This work presents a statistical tool for analysing large amounts of SERS data by utilizing a peak-fitting model in a specific spectral range. By analysing the distributions of Raman intensities and peak positions it is possible to directly inspect the interplay between DNA and 6-mercapto-1-hexanol on gold covered nanopillars. It is demonstrated that optimised functionalization parameters can be extracted from the Raman spectra directly. Using the peak-fitting approach it is possible to avoid miss-interpretation of intensity histograms, where contamination might contribute with an enhanced background and not a peak.
Syncopation affects free body-movement in musical groove

One of the most immediate and overt ways in which people respond to music is by moving their bodies to the beat. However, the extent to which the rhythmic complexity of groove—specifically its syncopation—contributes to how people spontaneously move to music is largely unexplored. Here, we measured free movements in hand and torso while participants listened to drum-breaks with various degrees of syncopation. We found that drum-breaks with medium degrees of syncopation were associated with the same amount of acceleration and synchronisation as low degrees of syncopation. Participants who enjoyed dancing made more complex movements than those who did not enjoy dancing. While for all participants hand movements accelerated more and were more complex, torso movements were more synchronised to the beat. Overall, movements were mostly synchronised to the main beat and half-beat level, depending on the body-part. We demonstrate that while people do not move or synchronise much to rhythms with high syncopation when dancing spontaneously to music, the relationship between rhythmic complexity and synchronisation is less linear than in simple finger-tapping studies.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Aarhus University, Dresden University of Technology, University of Oxford
Authors: Witek, M. A. G. (Ekstern), Popescu, T. (Ekstern), Clarke, E. F. (Ekstern), Hansen, M. (Ekstern), Konvalinka, I. (Intern), Kringelbach, M. L. (Ekstern), Vuust, P. (Ekstern)
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Task relevance differentially shapes ventral visual stream sensitivity to visible and invisible faces

Top-down modulations of the visual cortex can be driven by task relevance. Yet, several accounts propose that the perceptual inferences underlying conscious recognition involve similar top-down modulations of sensory responses. Studying the pure impact of task relevance on sensory responses requires dissociating it from the top-down influences underlying conscious recognition. Here, using visual masking to abolish perceptual consciousness in humans, we report
that functional magnetic resonance imaging (fMRI) responses to invisible faces in the fusiform gyrus are enhanced when they are task-relevant, but suppressed when they are task-irrelevant compared to other object categories. Under conscious perceptual conditions, task-related modulations were also present but drastically reduced, with visible faces always eliciting greater activity in the fusiform gyrus compared to other object categories. Thus, task relevance crucially shapes the sensitivity of fusiform regions to face stimuli, leading from enhancement to suppression of neural activity when the top-down influences accruing from conscious recognition are prevented.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Cognitive Systems, Ecole Normale Superieure, Pitié-Salpêtrière University Hospital, University of Oxford
Authors: Kouider, S. (Intern), Barbot, A. (Ekstern), Madsen, K. H. (Intern), Lehericy, S. (Ekstern), Summerfield, C. (Ekstern)
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The Center for Integrated Molecular Brain Imaging (Cimbi) database
We here describe a multimodality neuroimaging containing data from healthy volunteers and patients, acquired within the Lundbeck Foundation Center for Integrated Molecular Brain Imaging (Cimbi) in Copenhagen, Denmark. The data is of particular relevance for neurobiological research questions related to the serotonergic transmitter system with its normative data on the serotonergic subtype receptors 5-HT_{1A}, 5-HT_{1B}, 5-HT_{2A}, and 5-HT_{4}, and the 5-HT transporter (5-HTT), but can easily serve other purposes.

The Cimbi database and Cimbi biobank were formally established in 2008 with the purpose to store the wealth of Cimbi-acquired data in a highly structured and standardized manner in accordance with the regulations issued by the Danish Data Protection Agency as well as to provide a quality-controlled resource for future hypothesis-generating and hypothesis-driven studies. The Cimbi database currently comprises a total of 1100 PET and 1000 structural and functional MRI scans and it holds a multitude of additional data, such as genetic and biochemical data, and scores from 17 self-reported questionnaires and from 11 neuropsychological paper/computer tests.

The database associated Cimbi biobank currently contains blood and in some instances saliva samples from about 500 healthy volunteers and 300 patients with e.g., major depression, dementia, substance abuse, obesity, and impulsive aggression. Data continue to be added to the Cimbi database and biobank.

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Organisations: Copenhagen Center for Health Technology, Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital, University of Copenhagen, University of California, Rotman Research Institute
Authors: Knudsen, G. M. (Ekstern), Jensen, P. S. (Ekstern), Erritzoe, D. (Ekstern), Baaré, W. F. C. (Ekstern), Ettrup, A. (Ekstern), Fisher, P. M. (Ekstern), Gillings, N. (Ekstern), Hansen, H. D. (Ekstern), Hansen, L. K. (Intern), Hasselbalch, S.
The Functional Segregation and Integration Model: Mixture Model Representations of Consistent and Variable Group-Level Connectivity in fMRI

The brain consists of specialized cortical regions that exchange information between each other, reflecting a combination of segregated (local) and integrated (distributed) processes that define brain function. Functional magnetic resonance imaging (fMRI) is widely used to characterize these functional relationships, although it is an ongoing challenge to develop robust, interpretable models for high-dimensional fMRI data. Gaussian mixture models (GMMs) are a powerful tool for parcellating the brain, based on the similarity of voxel time series. However, conventional GMMs have limited parametric flexibility: they only estimate segregated structure and do not model interregional functional connectivity, nor do they account for network variability across voxels or between subjects. To address these issues, this letter develops the functional segregation and integration model (FSIM). This extension of the GMM framework simultaneously estimates spatial clustering and the most consistent group functional connectivity structure. It also explicitly models network variability, based on voxel- and subject-specific network scaling profiles. We compared the FSIM to standard GMM in a predictive cross-validation framework and examined the importance of different model parameters, using both simulated and experimental resting-state data. The reliability of parcellations is not significantly altered by flexibility of the FSIM, whereas voxel- and subject-specific network scaling profiles significantly improve the ability to predict functional connectivity in independent test data. Moreover, the FSIM provides a set of interpretable parameters to characterize both consistent and variable aspects functional connectivity structure. As an example of its utility, we use subject-specific network profiles to identify brain regions where network expression predicts subject age in the experimental data. Thus, the FSIM is effective at summarizing functional connectivity structure in group-level fMRI, with applications in modeling the relationships between network variability and behavioral/demographic variables.
The influence of hyper-parameters in the infinite relational model

The infinite relational model (IRM) is a Bayesian nonparametric stochastic block model; a generative model for random networks parameterized for uni-partite undirected networks by a partition of the node set and symmetric matrix of inter-partition link probabilities. The prior for the node clusters is the Chinese restaurant process, and the link probabilities are, in the most simple setting, modeled as iid. with a common symmetric Beta prior. More advanced priors such as separate asymmetric Beta priors for links within and between clusters have also been proposed. In this paper we investigate the importance of these priors for discovering latent clusters and for predicting links. We compare fixed symmetric priors and fixed asymmetric priors based on the empirical distribution of links with a Bayesian hierarchical approach where the parameters of the priors are inferred from data. On synthetic data, we show that the hierarchical Bayesian approach can infer the prior distributions used to generate the data. On real network data we demonstrate that using asymmetric priors significantly improves predictive performance and heavily influences the number of extracted partitions.
Otis media is a common disease in childhood. In adults, the disease is relatively rare, but more frequently associated with complications. Possible reasons for this discrepancy are age-related differences in pathogen exposure, anatomy of the Eustachian tube and immune system. The objective of this study was to analyze the relationship between age and the mucosal immune system in the middle ear. It is hypothesized that genes involved in the middle ear immune system will change with age. A comprehensive assessment of these genetic differences using the techniques of complementary DNA has not been performed. Complementary DNA microarray technology was used to identify immune-related genes differentially expressed between the normal middle ear mucosa of young (10 days old) and adult rats (80 days old). Data were analyzed using tools of bioinformatics. A total of 260 age-related genes were identified, of which 51 genes were involved in the middle ear mucosal immune system. Genes related to the innate immune system, including alpha-defensin, calcium-binding proteins S100A9 and S100A8, were upregulated in young rats, whereas genes related to the adaptive immune system, including CD3 molecules, zeta-chain T-cell receptor-associated protein kinase and linker of activated T-cells, were upregulated in the adult. This study concludes that the normal middle ear immune system changes with age. Genes related to the innate immune system are upregulated in young rats, whereas genes related to the adaptive immune system are upregulated in adults.
Towards Improving Overview and Metering through Visualisation and Dynamic Query Filters for User Interfaces
Implementing the Stage Metaphor for Music Mixing

This paper deals with challenges involved with implementing the stage metaphor control scheme for mixing music. Recent studies suggest that the stage metaphor outperforms the traditional channel-strip metaphor in several different ways. However, the implementation of the stage metaphor poses issues including clutter, lack of overview and monitoring of levels, and EQ. Drawing upon suggestions in recent studies, the paper describes the implementation of a stage metaphor prototype incorporating several features for dealing with these issues, including level and EQ monitoring using brightness, shape, and size. Moreover we explore the potential of using Dynamic Query filtering for localizing channels with certain properties of interest. Finally, an explorative user evaluation compares different variations of the prototype, leading to a discussion of the importance of each feature.

General information
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Towards Motion-Insensitive Magnetic Resonance Imaging Using Dynamic Field Measurements.
Magnetic resonance imaging (MRI) of the brain is frequently used for both clinical diagnosis and brain research. This is due to the great versatility of the technique and the excellent ability to distinguish different types of soft tissue. The image quality is, however, heavily degraded when the subject being scanned moves, which in many cases is impossible to avoid. Subject motion during scanning is therefore one of the big challenges for the method. Techniques to correct for image quality degradation due to subject motion are under rapid development. A promising approach is to monitor the head motion during scanning and update the MRI scanner in real-time such that the imaging volume follows the head motion (prospective motion correction). In this thesis, prospective motion correction is presented where head motion is determined from signals measured with an electroencephalography (EEG) cap with inter-connected electrodes that the subject wears during scanning. The signals measured with the EEG system are induced voltages due to temporal changes of the gradient fields. The signals contain information about the head position because these magnetic field changes are spatially depending, and because the induced voltages also depend on the orientation of the wire-loops relative to the direction of field changes. Some of the advantages with the developed technique are that it can be used in closed head coils where camera-based tracking is facing problems, and that it does not require additional hardware for the many hospitals and research institutions that already have an EEG-system for use in an MRI environment. In the thesis, the technique is considered in detail and proof of concept is demonstrated with phantom experiments. The experiments show that the newly developed technique has potential, but further optimization is required to improve accuracy and precision, and to improve the practical usability. During MR examinations, a radio frequency (RF) field is transmitted into the subject to tip the magnetization of the hydrogen nuclei in the body away from equilibrium, and measurable signal is emitted. Changes in the transmitted RF field due to subject motion has up to now largely been left undescribed in the literature. This effect of subject motion is considered in the second study of the thesis, which focuses on single voxel spectroscopy where the effects are believed to have significant impact. A linear model is proposed to estimate tip angle changes during the scan from motion parameters, e.g. obtained from an external tracking system. The technique requires a previously performed calibration scan where the tip angle changes are measured for different head positions. A method for measuring actual tip angle changes was therefore implemented and pilot experiments were performed in a phantom and a healthy volunteer. The simple model seems promising based on these preliminary results. In MRI of the brain, not only head motion, but also motion of other parts of the body can lead to image degradation. This is because tissue is magnetized by the very strong, static background field (B0) such that the tissue contributes slightly to the background field. Motion of the body is thus felt in the brain as small fluctuations in the background field, and e.g. breathing motion can lead to substantial image quality degradation for certain brain imaging sequences through this effect. It has previously been shown that magnetic field sensors (field probes) can be applied to stabilize the B0 field during scanning. However, the field probes are placed around the head, while it is the B0-fluctuations inside the head that are of interest. This interpolation problem is the subject of the last study in the thesis. Experiments were performed with healthy volunteers to test how field estimates in the brain based on outside field probe measurements compare to field measurements performed in the brain, in cases with breathing and shoulder motion. Simulations were performed to elucidate where the field probes should be placed in order to optimize the correspondence.

General information
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Organisations: Department of Electrical Engineering, Center for Magnetic Resonance, Center for Hyperpolarization in Magnetic Resonance, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Andersen, M. (Intern), Hanson, L. G. (Intern), Madsen, K. H. (Intern)
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Training shortest-path tractography: Automatic learning of spatial priors
Tractography is the standard tool for automatic delineation of white matter tracts from diffusion-weighted images. However, the output of tractography often requires post-processing to remove false positives and ensure a robust delineation of the studied tract, and this demands expert prior knowledge. Here we demonstrate how such prior knowledge, or indeed any prior spatial information, can be automatically incorporated into a shortest-path tractography approach to produce more robust results. We describe how such a prior can be automatically generated (learned) from a
population, and we demonstrate that our framework also retains support for conventional interactive constraints such as
waypoint regions. We apply our approach to the open access, high quality Human Connectome Project data, as well as a
dataset acquired on a typical clinical scanner. Our results show that the use of a learned prior substantially increases the
overlap of tractography output with a reference atlas on both populations, and this is confirmed by visual inspection.
Furthermore, we demonstrate how a prior learned on the high quality dataset significantly increases the overlap with the
reference for the more typical yet lower quality data acquired on a clinical scanner. We hope that such automatic
incorporation of prior knowledge and the obviation of expert interactive tract delineation on every subject, will improve the
feasibility of large clinical tractography studies.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of
Copenhagen, Copenhagen University Hospital
Authors: Kasenburg, N. (Ekstern), Liptrot, M. G. (Intern), Reislev, N. L. (Ekstern), Orting, S. N. (Ekstern), Nielsen, M.
(Ekstern), Garde, E. (Ekstern), Feragen, A. (Ekstern)
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Web of Science (2011): Indexed yes
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.954 SNIP 1.899
Web of Science (2009): Indexed yes
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Using Concrete and Realistic Data in Evaluating Initial Visualization Designs

We explore means of designing and evaluating initial visualization ideas, with concrete and realistic data in cases where data is not readily available. Our approach is useful in exploring new domains and avenues for visualization, and contrasts other visualization work, which typically operate under the assumption that data has already been collected, and is ready to be visualized. We argue that it is sensible to understand data requirements and evaluate the potential value of visualization before devising means of automatic data collection. We base our exploration on three cases selected to span a range of factors, such as the role of the person doing the data collection and the type of instrumentation used. The three cases relate to visualizing sports, construction, and cooking domain data, and use primarily time-domain data and visualizations. For each case, we briefly describe the design case and problem, the manner in which we collected data, and the findings obtained from evaluations. Afterwards, we describe four factors of our data collection approach, and discuss potential outcomes from it.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Knudsen, S. (Ekstern), Pedersen, J. G. (Ekstern), Herdal, T. (Ekstern), Larsen, J. E. (Intern)
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Methodology, InfoVis, Personal visualization, Evaluation, Pre-design empiricism
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Variational group-PCA for intrinsic dimensionality determination in fMRI data

Functional Magnetic Resonance Imaging (fMRI) is widely used to gain a better understanding of the human brain's functional organization. As fMRI data are high dimensional it is challenging to analyse using conventional methods thus low-rank approximations such as principal component analysis (PCA), and independent component analysis (ICA) is often applied as a preprocessing step before any additional analysis. Low-rank methods generally require that the rank or latent dimensionality is known beforehand. When this is not the case a range of plausible dimensionalities have to be tested and compared. Furthermore, in an fMRI-context it is not fully understood how information from multiple subjects should best be incorporated when applying dimensionality reduction. We propose a Bayesian group principal component analysis (Group-BPCA) model with an automatic relevance determination (ARD) prior to determine the number of active components supported by the data. All subjects share the same spatial maps (components), but the uncertainties on these maps as well as the noise is subject specific. We find an approximate solution using the mature variational Bayesian framework and develop a fast and scalable implementation using a graphical processing unit (GPU). We test the model on fMRI data from 29 healthy subjects performing a block-design finger-tapping experiment. The model identified 10 active components. Neither variational Bayesian PCA on temporally concatenated data nor Group-BPCA, where uncertainties on the spatial maps are shared, leads to pruning components, but provide better generalization in two of three scenarios. We show that the right level of subject variability is highly dependent on the chosen validation scheme.

General information
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Organisations: Cognitive Systems, Department of Applied Mathematics and Computer Science
Authors: Hinrich, J. L. (Intern), Nielsen, S. F. V. (Intern), Madsen, K. H. (Intern), Mørup, M. (Intern)
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Voice analysis as an objective state marker in bipolar disorder

Changes in speech have been suggested as sensitive and valid measures of depression and mania in bipolar disorder. The present study aimed at investigating (1) voice features collected during phone calls as objective markers of affective states in bipolar disorder and (2) if combining voice features with automatically generated objective smartphone data on behavioral activities (for example, number of text messages and phone calls per day) and electronic self-monitored data (mood) on illness activity would increase the accuracy as a marker of affective states. Using smartphones, voice features, automatically generated objective smartphone data on behavioral activities and electronic self-monitored data were collected from 28 outpatients with bipolar disorder in naturalistic settings on a daily basis during a period of 12 weeks. Depressive and manic symptoms were assessed using the Hamilton Depression Rating Scale 17-item and the Young Mania Rating Scale, respectively, by a researcher blinded to smartphone data. Data were analyzed using random forest algorithms. Affective states were classified using voice features extracted during everyday life phone calls. Voice features were found to be more accurate, sensitive and specific in the classification of manic or mixed states with an area under the curve (AUC)=0.89 compared with an AUC=0.78 for the classification of depressive states. Combining voice features with automatically generated objective smartphone data on behavioral activities and electronic self-monitored data increased the accuracy, sensitivity and specificity of classification of affective states slightly. Voice features collected in naturalistic settings using smartphones may be used as objective state markers in patients with bipolar disorder.

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Organisations: Copenhagen Center for Health Technology, Department of Applied Mathematics and Computer Science , Cognitive Systems, Embedded Systems Engineering, Rigshospitalet, IT University of Copenhagen
Authors: Faurholt-Jepsen, M. (Ekstern), Busk, J. (Intern), Frost, M. (Ekstern), Vinberg, M. (Ekstern), Christensen, E. M. (Ekstern), Winther, O. (Intern), Bardram, J. E. (Intern), Kessing, L. V. (Ekstern)
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Voice analysis as an objective state marker in bipolar disorder

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Authors: Faurholt-Jepsen, M. (Ekstern), Busk, J. (Ekstern), Frost, M. (Ekstern), Vinberg, M. (Ekstern), Christensen, E. M. (Ekstern), Winther, O. (Intern), Bardram, J. E. (Intern), Kessing, L. V. (Ekstern)
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Voice analysis as an objective state marker in bipolar disorder
This invention relates to a system for and a method (100) of searching a collection of digital information (150) comprising a number of digital documents (110), the method comprising receiving or obtaining (102) a search query, the query comprising a number of search terms, searching (103) an index (300) using the search terms thereby providing information (301) about which digital documents (110) of the collection of digital information (150) that contains a given search term and one or more search related metrics (302; 303; 304; 305; 306), ranking (105) at least a part of the search result according to one or more predetermined criteria providing a ranked search result, and providing at least a part of the ranked search result (106), wherein the ranking provides robust likelihood for low count terms by using the one or more search related metrics (302; 303; 304; 305; 306). In this way, a method of and a system for information retrieval or searching is readily provided that enhances the searching quality (i.e. the number of relevant documents retrieved and such documents being ranked high) when (also) using queries containing many search terms.
A genomewide catalogue of single nucleotide polymorphisms in white-beaked and Atlantic white-sided dolphins
The field of population genetics is rapidly moving into population genomics as the quantity of data generated by high-throughput sequencing platforms increases. In this study, we used restriction-site-associated DNA sequencing (RADSeq) to recover genomewide genotypes from 70 white-beaked (Lagenorhynchus albirostris) and 43 Atlantic white-sided dolphins (L. acutus) gathered throughout their north-east Atlantic distribution range. Both species are at a high risk of being negatively affected by climate change. Here, we provide a resource of 38 240 RAD-tags and 52 981 nuclear SNPs shared between both species. We have estimated overall higher levels of nucleotide diversity in white-sided (π = 0.0492 ± 0.0006%) than in white-beaked dolphins (π = 0.0300 ± 0.0004%). White-sided dolphins sampled in the Faroe Islands, belonging to two pods (N = 7 and N = 11), showed similar levels of diversity (π = 0.0317 ± 0.0007% and 0.0267 ± 0.0006%, respectively) compared to unrelated individuals of the same species sampled elsewhere (e.g. π = 0.0285 ± 0.0007% for 11 Scottish individuals). No evidence of higher levels of kinship within pods can be derived from our analyses. When identifying the most likely number of genetic clusters among our sample set, we obtained an estimate of two to four clusters, corresponding to both species and possibly, two further clusters within each species. A higher diversity and lower population structuring was encountered in white-sided dolphins from the north-east Atlantic, in line with their preference for pelagic waters, as opposed to white-beaked dolphins that have a more patchy distribution, mainly across continental shelves.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, SAC Veterinary Services, Marine Research Institute, University of Veterinary Medicine Hannover, Fisheries and Maritime Museum, Institute of Marine Research, Irish Whale and Dolphin Group, University College Cork, Universite de La Rochelle, King Saud University, Natural History Museum
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Scopus rating (2016): CiteScore 6.06 SJR 2.986 SNIP 2.157
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.327 SNIP 1.55 CiteScore 4.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.836 SNIP 2.206 CiteScore 5.04
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 3.496 SNIP 2.968 CiteScore 7.31
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Airway Inflammation in Chronic Rhinosinusitis with Nasal Polyps and Asthma: The United Airways Concept Further Supported

Background It has been established that patients with chronic rhinosinusitis with nasal polyps (CRSwNP) often have co-existing asthma. Objective We aimed to test two hypotheses: (i) upper and lower airway inflammation in CRSwNP is uniform in agreement with the united airways concept; and (ii) bronchial inflammation exists in all CRSwNP patients irrespective of clinical asthma status. Methods We collected biopsies from nasal polyps, inferior turbinates and bronchi of 27 CRSwNP patients and 6 controls. All participants were evaluated for lower airway disease according to international guidelines. Inflammatory cytokines were investigated using a Th1/Th2 assay including 14 chemokines and cytokines; tissue concentrations were normalized according to tissue weight and total protein concentration. Individual cytokines and multivariate inflammatory profiles were compared between biopsy sites and between patients and controls. Results We found significantly higher concentrations of Th2 cytokines in nasal polyps compared to inferior turbinate and bronchial biopsies. In addition, we showed that the inflammatory profile of nasal polyps and bronchial biopsies correlated significantly (p<0.01). From the Th2 cytokines measured, IL-13 was significantly increased in bronchial biopsies from CRSwNP patients with, but not without asthma. Conclusion Our findings support the united airways concept; however, we did not find evidence for subclinical bronchial inflammation in CRSwNP patients without asthma. Finally, this study indicates for the first time that nasal polyps potentially play an important role in the airway inflammation rather than being a secondary phenomenon.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Karolinska Institutet
Authors: Häkansson, K. (Ekstern), Bachert, C. (Ekstern), Konge, L. (Ekstern), Thomsen, S. F. (Ekstern), Pedersen, A. E. (Ekstern), Poulsen, S. S. (Ekstern), Martin-Bertelsen, T. (Ekstern), Winther, O. (Intern), Backer, V. (Ekstern), von Buchwald, C. (Ekstern)
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.614 SNIP 1.046
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
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**A Random Riemannian Metric for Probabilistic Shortest-Path Tractography**

Shortest-path tractography (SPT) algorithms solve global optimization problems defined from local distance functions. As diffusion MRI data is inherently noisy, so are the voxelwise tensors from which local distances are derived. We extend Riemannian SPT by modeling the stochasticity of the diffusion tensor as a "random Riemannian metric", where a geodesic is a distribution over tracts. We approximate this distribution with a Gaussian process and present a probabilistic numerics algorithm for computing the geodesic distribution. We demonstrate SPT improvements on data from the Human Connectome Project.
A Spatial Model for the Instantaneous Estimation of Wind Power at a Large Number of Unobserved Sites

We propose a hierarchical Bayesian spatial model to obtain predictive densities of wind power at a set of un-monitored locations. The model consists of a mixture of Gamma density for the non-zero values and degenerated distributions at zero. The spatial dependence is described through a common Gaussian random field with a Matérn covariance. For inference and prediction, we use the GMRF-SPDE approximation implemented in the R-INLA package. We showcase the method outlined here on data for 336 wind farms located in Denmark. We test the predictions derived from our method with model-diagnostic tools and show that it is calibrated.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Energy Analytics and Markets
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Audiovisual Integration of Speech in a Patient with Broca's Aphasia

Lesions to Broca's area cause aphasia characterized by a severe impairment of the ability to speak, with comparatively intact speech perception. However, some studies have found effects on speech perception under adverse listening conditions, indicating that Broca's area is also involved in speech perception. While these studies have focused on auditory speech perception other studies have shown that Broca's area is activated by visual speech perception. Furthermore, one preliminary report found that a patient with Broca's aphasia did not experience the McGurk illusion suggesting that an intact Broca's area is necessary for audiovisual integration of speech. Here we describe a patient with Broca's aphasia who experienced the McGurk illusion. This indicates that an intact Broca's area is not necessary for audiovisual integration of speech. The McGurk illusions this patient experienced were atypical, which could be due to Broca's area having a more subtle role in audiovisual integration of speech. The McGurk illusions of a control subject with Wernicke's aphasia were, however, also atypical. This indicates that the atypical McGurk illusions were due to deficits in speech processing that are not specific to Broca's aphasia.

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.25 SNIP 0.916 CiteScore 2.29
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.534 SNIP 1.033 CiteScore 2.71
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.395 SNIP 0.856 CiteScore 2.43
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 1.42 SNIP 0.952 CiteScore 2.39
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Acute myeloid leukemia (AML) represents an aggressive cancer entity, whose malignant cells respond abnormally to regulatory stimuli and have lost the ability to differentiate and become fully mature blood cells.\textsuperscript{1, 2} AML evolves through accumulation of independent genetic aberrations, including chromosomal structural rearrangements and single nucleotide variants (SNVs). Conventional AML diagnostics and recent seminal next-generation sequencing (NGS) studies have identified more than 200 recurrent genetic aberrations presenting in various combinations in individual patients. Significantly, many of these aberrations occur in normal hematopoietic stem and progenitor cells (HSCs/HPCs) before definitive leukemic transformation through additional acquisition of a few (that is, mostly 1 or 2) leukemia-promoting driver aberrations. NGS studies on sorted bone marrow (BM) populations of AML patients with a normal karyotype have demonstrated the presence of prognostic driver aberrations (that is, NPM1, FLT3-ITD and FLT3-TKD) in committed HPCs but not in multipotent HSCs. However, the HSC populations lacking the prognostic driver aberrations contained preleukemic clones harboring a series of recurrent molecular aberrations that were present in the fully transformed committed HPCs together with the prognostic driver aberration. Adding to this vast heterogeneity and complexity of AML genomes and their clonal evolution, a recent study of a murine AML model demonstrated that t(9;11) AML originating from HSCs responded poorly to in vivo chemotherapy treatment as compared with t(9;11) AML originating from HPCs.
Classification of independent components of EEG into multiple artifact classes

In this study, we aim to automatically identify multiple artifact types in EEG. We used multinomial regression to classify independent components of EEG data, selecting from 65 spatial, spectral, and temporal features of independent components using forward selection. The classifier identified neural and five nonneural types of components. Between subjects within studies, high classification performances were obtained. Between studies, however, classification was more difficult. For neural versus nonneural classifications, performance was on par with previous results obtained by others. We found that automatic separation of multiple artifact classes is possible with a small feature set. Our method can reduce manual workload and allow for the selective removal of artifact classes. Identifying artifacts during EEG recording may be used to instruct subjects to refrain from activity causing them.

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Business School
Authors: Etter, M. (Ekstern), Nielsen, F. Å. (Intern)
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Main Research Area: Technical/natural sciences
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Purpose – How organizations' pasts are presented to the public is crucial, because this presentation shapes corporate reputations. Increasingly, various actors contribute to the public remembering of organizations with new information and communication technologies (ICTs). The purpose of this paper is to investigate the online encyclopedia Wikipedia as a global memory place, where the pasts of organizations are communicatively co-constructed by actors of a loosely connected community.

Design/methodology/approach – The authors analyze 1,459 edits of Wikipedia pages of ten organizations from various industries. Quantitative content analysis detects Wikipedia edits for their reputational relevance and reference to formal sources, such as corporate communication or newspapers. Furthermore, the authors investigate to which degree current corporate communication in form of 177 press releases has an influence on the remembering process in Wikipedia.

Findings – The analysis shows how the continuous construction of collective memories bridges past formal corporate communication, news media, and other sources with the present, exposing, and suppressing relevant information concerning corporate reputation for large audiences. The analysis of press releases shows that current frames provided by corporate communication finds only little resonance in the ongoing remembering processes in Wikipedia.

Originality/value – Conventional approaches toward remembering of organizations embrace an organization centric view, whereby corporate communication strategically leverages organizational pasts. This paper contributes to the understanding of the ongoing, networked, and collective co-construction of organizational pasts by various authors through ICTs.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Business School
Authors: Etter, M. A. (Ekstern), Nielsen, F. Å. (Intern)
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Issue number: 4
ISSN (Print): 1356-3289
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Scopus rating (2017): SNIP 0.73 SJR 0.453
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.703 SNIP 1.379 CiteScore 1.86
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.737 SNIP 1.092 CiteScore 1.81
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.66 SNIP 1.204 CiteScore 1.46
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.435 SNIP 0.938 CiteScore 1.15
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.664 SNIP 0.786 CiteScore 1.26
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.405 SNIP 0.898 CiteScore 1.01
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.339 SNIP 0.535
BFI (2009): BFI-level 2
Combining text mining and coordinate-based meta-analysis

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Nielsen, F. Å. (Intern)
Number of pages: 27
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Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
NielsenF2015Combining_slides.pdf

Relations
Activities:
Combining text mining and coordinate-based meta-analysis
Publication: Research › Sound/Visual production (digital) – Annual report year: 2015

Convolutional LSTM Networks for Subcellular Localization of Proteins

Machine learning is widely used to analyze biological sequence data. Non-sequential models such as SVMs or feed-forward neural networks are often used although they have no natural way of handling sequences of varying length. Recurrent neural networks such as the long short term memory (LSTM) model on the other hand are designed to handle sequences. In this study we demonstrate that LSTM networks predict the subcellular location of proteins given only the protein sequence with high accuracy (0.902) outperforming current state of the art algorithms. We further improve the performance by introducing convolutional filters and experiment with an attention mechanism which lets the LSTM focus on specific parts of the protein. Lastly we introduce new visualizations of both the convolutional filters and the attention mechanisms and show how they can be used to extract biologically relevant knowledge from the LSTM networks.

General information
State: Published
Organisations: Department of Systems Biology, Center for Biological Sequence Analysis, Functional Human Variation, Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Sønderby, S. K. (Ekstern), Sønderby, C. K. (Ekstern), Nielsen, H. (Intern), Winther, O. (Intern)
Number of pages: 13
Pages: 68-80
Publication date: 2015
CRIM-TRACK: Sensor System for Detection of Criminal Chemical Substances

Detection of illegal compounds requires a reliable, selective and sensitive detection device. The successful device features automated target acquisition, identification and signal processing. It is portable, fast, user friendly, sensitive, specific, and cost efficient. LEAs are in need of such technology. CRIM-TRACK is developing a sensing device based on these requirements. We engage highly skilled specialists from research institutions, industry, SMEs and LEAs and rely on a team of end users to benefit maximally from our prototypes. Currently we can detect minute quantities of drugs, explosives and precursors thereof in laboratory settings. Using colorimetric technology we have developed prototypes that employ disposable sensing chips. Ease of operation and intuitive sensor response are highly prioritized features that we implement as we gather data to feed into machine learning. With machine learning our ability to detect threat compounds amidst harmless substances improves. Different end users prefer their equipment optimized for their specific field. In an explosives-detecting scenario, the end user may prefer false positives over false negatives, while the opposite may be true in a drug-detecting scenario. Such decisions will be programmed to match user preference. Sensor output can be as detailed as the sensor allows. The user can be informed of the statistics behind the detection, identities of all detected substances, and quantities thereof. The response can also be simplified to “yes” vs. “no”. The technology under development in CRIM-TRACK will provide custom officers, police and other authorities with an effective tool to control trafficking of illegal drugs and drug precursors.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Department of Micro- and Nanotechnology, Surface Engineering, Cognitive Systems, Cranfield University, Pro Design Electronic GmbH, Securetec Detektions-Systeme AG, Gammadata Instrument AB
Authors: Munk, J. K. (Intern), Buus, O. T. (Intern), Larsen, J. (Intern), Dossi, E. (Ekstern), Tatlow, S. (Ekstern), Lässig, L. (Ekstern), Sandström, L. (Ekstern), Jakobsen, M. H. (Intern)
Pages: 1-5
Publication date: 2015
Deep Belief Nets for Topic Modeling

Applying traditional collaborative filtering to digital publishing is challenging because user data is very sparse due to the high volume of documents relative to the number of users. Content based approaches, on the other hand, is attractive because textual content is often very informative. In this paper we describe large-scale content based collaborative filtering for digital publishing. To solve the digital publishing recommender problem we compare two approaches: latent Dirichlet allocation (LDA) and deep belief nets (DBN) that both find low-dimensional latent representations for documents. Efficient retrieval can be carried out in the latent representation. We work both on public benchmarks and digital media content provided by Issuu, an on-line publishing platform. This article also comes with a newly developed deep belief nets toolbox for topic modeling tailored towards performance evaluation of the DBN model and comparisons to the LDA model.

Deep Learning and Music Adversaries

An adversary is an agent designed to make a classification system perform in some particular way, e.g., increase the probability of a false negative. Recent work builds adversaries for deep learning systems applied to image object recognition, exploiting the parameters of the system to find the minimal perturbation of the input image such that the system misclassifies it with high confidence. We adapt this approach to construct and deploy an adversary of deep learning systems applied to music content analysis. In our case, however, the system inputs are magnitude spectral frames, which require special care in order to produce valid input audio signals from network-derived perturbations. For two different train-test partitionings of two benchmark datasets, and two different architectures, we find that this adversary is very effective. We find that convolutional architectures are more robust compared to systems based on a majority vote over individually classified audio frames. Furthermore, we experiment with a new system that integrates an adversary into the training loop, but do not find that this improves the resilience of the system to new adversaries.
Deep learning, audio adversaries, and music content analysis

We present the concept of adversarial audio in the context of deep neural networks (DNNs) for music content analysis. An adversary is an algorithm that makes minor perturbations to an input that cause major repercussions to the system response. In particular, we design an adversary for a DNN that takes as input short-time spectral magnitudes of recorded
music and outputs a high-level music descriptor. We demonstrate how this adversary can make the DNN behave in any way with only extremely minor changes to the music recording signal. We show that the adversary cannot be neutralised by a simple filtering of the input. Finally, we discuss adversaries in the broader context of the evaluation of music content analysis systems.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Queen Mary University of London
Authors: Kereliuk, C. M. (Intern), Sturm, B. L. (Ekstern), Larsen, J. (Intern)
Pages: 1-5
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BFI conference series: Workshop on Applications of Signal Processing to Audio and Acoustics (5010542)
Main Research Area: Technical/natural sciences
Workshop: IEEE Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA 2015), New Paltz, New York, United States, 18/10/2015 - 18/10/2015
Deep Learning, Music Content Analysis
DOIs:
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Source-ID: 276858747
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

**Degradation studies of spray coated polymer films using cantilever sensors**

**General information**
State: Published
Organisations: Center for Nanostructured Graphene, Department of Micro- and Nanotechnology, Amphiphilic Polymers in Biological Sensing, Nanoprobes, Biomaterial Microsystems, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Almdal, K. (Intern), Bose, S. (Intern), Keller, S. S. (Intern), Alstrøm, T. S. (Intern), Boisen, A. (Intern)
Number of pages: 1
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Event: Poster session presented at Fourth International Symposium Frontiers in Polymer Science, Riva del Garda, Italy.
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Publication: Research - peer-review › Poster – Annual report year: 2015

**Differential Gene Expression in the Otic Capsule and the Middle Ear-An Annotation of Bone-Related Signaling Genes**

Hypothesis: A number of bone-related genes may be responsible for the unique suppression of perilabyrinthine bone remodeling. Background: Bone remodeling is highly inhibited around the inner ear space most likely because of osteoprotegerin (OPG), which is a well-known potent inhibitor of osteoclast formation and function. However, other signaling molecules may also be responsible for the inhibition of bone remodeling within the otic capsule.

Methods: Microarray technology was used to determine bone-related genes differentially expressed between the lining tissues of the otic capsule (spiral ligament and stria vascularis) and the lining tissues from the middle ear of the rat. Data was analyzed with statistical bioinformatics tools. Gene expression levels of selected genes were validated using quantitative polymerase chain reaction. Results: A total of 413 genes were identified when young inner bulla (growing) were compared with young otic capsule and 358 genes were identified when adult inner bulla (quiescent) were compared with adult otic capsule. Fourteen genes were involved in bone metabolism of which four genes have been previously discussed in the literature of perilabyrinthine bone biology.

Conclusion: The gene expression of the otic capsule was significantly different from that of the middle ear. This study identified a number of differentially expressed bone-related mRNAs of potential significance and confirmed the OPG/receptor activator of nuclear factor kappa-B (RANK)/RANK ligand (RANKL) pathway as the key signaling system for the unique behavior of bone cells within the otic capsule. No differentially expressed up-or downstream messengers in the OPG/RANK/RANKL pathway were found.
Digital daily cycles of individuals
Humans, like almost all animals, are phase-locked to the diurnal cycle. Most of us sleep at night and are active through the day. Because we have evolved to function with this cycle, the circadian rhythm is deeply ingrained and even detectable at the biochemical level. However, within the broader day-night pattern, there are individual differences: e.g., some of us are intrinsically morning-active, while others prefer evenings. In this article, we look at digital daily cycles: circadian patterns of activity viewed through the lens of auto-recorded data of communication and online activity. We begin at the aggregate level, discuss earlier results, and illustrate differences between population-level daily rhythms in different media. Then we move on to the individual level, and show that there is a strong individual-level variation beyond averages: individuals typically have their distinctive daily pattern that persists in time. We conclude by discussing the driving forces behind these signature daily patterns, from personal traits (morningness/eveningness) to variation in activity level and external constraints, and outline possibilities for future research.
Dynamics of High-Resolution Networks
NETWORKS are everywhere. From the smallest confines of the cells within our bodies to the webs of social relations across the globe. Networks are not static, they constantly change, adapt, and evolve to suit new conditions. In order to understand the fundamental laws that govern networks we need new, highly detailed maps that uncover the interactions of all constituents, accurately and in a temporal manner. One of the hardest networks to understand, but also one of the most interesting ones, is the human social network. How do humans interact, form friendships, and spread information? And how are we all affected by an ever changing network structure? Answering these questions will enrich our understanding of ourselves, our organizations, and our societies. Yet, mapping the dynamics of social networks has traditionally been an arduous undertaking. Today, however, it is possible to use the unprecedented amounts of information collected by mobile phones to gain detailed insight into the dynamics of social systems. This dissertation presents an unparalleled data collection campaign, collecting highly detailed traces for approximately 1000 people over the course of multiple years. The availability of such dynamic maps allows us to probe the underlying social network and understand how individuals interact and form lasting friendships. More importantly, these highly detailed dynamic maps provide us new perspectives at traditional problems and allow us to quantify and predict human life.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Sekara, V. (Intern), Jørgensen, S. L. (Intern)
Number of pages: 189
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Electronic versions:
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EEG Source Reconstruction Performance as a Function of Skull Conductance Contrast
Through simulated EEG we investigate the effect of the forward model's applied skull:scalp conductivity ratio on the source reconstruction performance. We show that having a higher conductivity ratio generally leads to improvement of the solution. Additionally we see a clear connection between higher conductivity ratios and lower coherence, thus a reduction of the ill-posedness of the EEG inverse problem. Finally we show on real EEG data the stability of the strongest source recovered across conductivity ratios.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Hansen, S. T. (Intern), Hansen, L. K. (Intern)
Pages: 827-831
Publication date: 2015

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BFI conference series: International Conference on Acoustics, Speech and Signal Processing (5010123)
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EEG source reconstruction, Inverse problem, Forward models, Sparsity, Variational approximation
Electronic versions:
HansenUp.pdf
DOIs:
10.1109/ICASSP.2015.7178085
¿El Caballo Viejo? Latin Genre Recognition with Deep Learning and Spectral Periodicity

The “winning” system in the 2013 MIREX Latin Genre Classification Task was a deep neural network trained with simple features. An explanation for its winning performance has yet to be found. In previous work, we built similar systems using the BALLROOM music dataset, and found their performances to be greatly affected by slightly changing the tempo of the music of a test recording. In the MIREX task, however, systems are trained and tested using the Latin Music Dataset (LMD), which is 4.5 times larger than BALLROOM, and which does not seem to show as strong a relationship between tempo and label as BALLROOM. In this paper, we reproduce the “winning” deep learning system using LMD, and measure the effects of time dilation on its performance. We find that tempo changes of at most ±6 % greatly diminish and improve its performance. Interpreted with the low-level nature of the input features, this supports the conclusion that the system is exploiting some low-level absolute time characteristics to reproduce ground truth in LMD.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Queen Mary University of London
Authors: Sturm, B. L. (Ekstern), Kereliuk, C. M. (Intern), Larsen, J. (Intern)
Pages: 335-346
Publication date: 2015

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Series: Lecture Notes in Computer Science
Volume: 9110
ISSN: 0302-9743
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Main Research Area: Technical/natural sciences
Conference: 5th International Conference on Mathematics and Computation in Music (MCM 2015), London, United Kingdom, 22/06/2015 - 22/06/2015
Machine music listening, Genre, Deep Learning, Evaluation
DOIs: 10.1007/978-3-319-20603-5_34
Source: FindIt
Source-ID: 275282381
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Enhanced computational methods for quantifying the effect of geographic and environmental isolation on genetic differentiation

Motivation In a recent paper, Bradburd et al. [2013] proposed a model to quantify the relative effect of geographic and environmental distance on genetic differentiation. Here, we enhance this method in several ways.

Results (i) We modify the covariance model so as to fit better with mainstream geostatistical models and avoid mathematically illbehaved covariance functions, (ii) we extend the model - initially implemented only for co-dominant bi-allelic markers such as SNPs - to encompass highly polymorphic markers such as microsatellites, (iii) we implement and test a model selection procedure that allows users to assess which model (e.g. with or without an environment effect) is most suited, (iv) we extend the program to handle several environmental variables jointly, (v) we code all our MCMC algorithms in a mix of compiled languages which allows us to decrease computing time by at least one order of magnitude, (vi) we propose an approximate inference and model selection method allowing to deal with a large number of loci. We also illustrate the potential of the method by re-analyzing three datasets relative to harbour porpoises in Europe, coyotes in California and herrings in the Baltic Sea.

Availability The computer program developed here is freely available as an R package called SUNDER. It takes as input geo-referenced allele counts at the individual or population level for co-dominant markers. Programe homepage: www2.imm.dtu.dk/~gigu/Sunder

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Technical University of Denmark, University of Groningen
Enhanced computational methods for quantifying the effect of geographic and environmental isolation on genetic differentiation
1. In a recent paper, Bradburd et al. (Evolution, 67, 2013, 3258) proposed a model to quantify the relative effect of geographic and environmental distance on genetic differentiation. Here, we enhance this method in several ways.
2. We modify the covariance model so as to fit better with mainstream geostatistical models and avoid mathematically ill-behaved covariance functions. We extend the model – initially implemented only for co-dominant bi-allelic markers such as single nucleotide polymorphisms – to encompass highly polymorphic markers such as microsatellites. We implement and test a model selection procedure that allows users to assess which model (e.g. with or without an environment effect) is most suited. We code all our MCMC algorithms in a mix of compiled languages which allows us to decrease computing time by at least one order of magnitude. We propose an approximate inference and model selection method allowing us to deal with genomic data sets (several hundred thousands loci).
3. We also illustrate the potential of the method by re-analysing three data sets, namely harbour porpoises in Europe, coyotes in California and herrings in the Baltic Sea.
4. The computer program developed here is freely available as an R package called sunder. It takes as input georeferenced allele counts at the individual or population level for co-dominant markers. Program homepage: http://www2.imm.dtu.dk/~gigu/Sunder/.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark, University of Groningen
Authors: Botta, F. (Intern), Eriksen, C. (Ekstern), Fontaine, M. C. (Ekstern), Guillot, G. (Intern)
Pages: 1270-1277
Publication date: 2015
Face configuration affects speech perception: Evidence from a McGurk mismatch negativity study

We perceive identity, expression and speech from faces. While perception of identity and expression depends crucially on the configuration of facial features it is less clear whether this holds for visual speech perception.

Facial configuration is poorly perceived for upside-down faces as demonstrated by the Thatcher illusion in which the orientation of the eyes and mouth with respect to the face is inverted (Thatcherization). This gives the face a grotesque appearance but this is only seen when the face is upright.

Thatcherization can likewise disrupt visual speech perception but only when the face is upright indicating that facial configuration can be important for visual speech perception. This effect can propagate to auditory speech perception through audiovisual integration so that Thatcherization disrupts the McGurk illusion in which visual speech perception alters perception of an incongruent acoustic phoneme. This is known as the McThatcher effect.

Here we show that the McThatcher effect is reflected in the McGurk mismatch negativity (MMN). The MMN is an event-related potential elicited by a change in auditory perception. The McGurk-MMN can be elicited by a change in auditory perception due to the McGurk illusion without any change in the acoustic stimulus.

We found that Thatcherization disrupted a strong McGurk illusion and a correspondingly strong McGurk-MMN only for upright faces. This confirms that facial configuration can be important for audiovisual speech perception. For inverted
faces we found a weaker McGurk illusion but, surprisingly, no MMN. We also found no correlation between the strength of
the McGurk illusion and the amplitude of the McGurk-MMN. We suggest that this may be due to a threshold effect so that
a strong McGurk illusion is required to elicit the McGurk-MMN.
**Functional Analysis: Entering Hilbert Space**

In the second edition, I have expanded the material on normed vector spaces and their operators presented in Chapter 1 to include proofs of the Open Mapping Theorem, the Closed Graph Theorem and the Hahn-Banach Theorem. The material on operators between normed vector spaces is further expanded in a new chapter on Fredholm theory (Chapter 6). Fredholm theory originates in pioneering work of the Swedish mathematician Erik Ivar Fredholm on integral equations, which inspired the study of a new class of bounded linear operators, known as Fredholm operators. Chapter 6 presents the basic elements of the theory of Fredholm operators on general Banach spaces, not only on Hilbert spaces, since this is important for applications of the theory.

The more general setting with Banach spaces requires that we develop the theory of dual operators between Banach spaces to replace the use of adjoint operators between Hilbert spaces. Fredholm operators are of interest far beyond mathematical analysis, they also play a significant role in theoretical physics, differential geometry and topology with the famous Index Theorem proved by Michael Atiyah and Isadore Singer in 1963 as a highlight.

With the addition of the new material on normed vector spaces and their operators, the book can hopefully serve as a general introduction to functional analysis viewed as a theory of infinite dimensional linear spaces and linear operators acting on them.

**General information**

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Authors: Hansen, V. L. (Intern)
Number of pages: 173
Publication date: 2015

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Original language: English
Main Research Area: Technical/natural sciences
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**Fusing Simultaneous EEG and fMRI Using Functional and Anatomical Information**

Simultaneously measuring electro physical and hemodynamic signals has become more accessible in the last years and the need for modeling techniques that can fuse the modalities is growing. In this work we augment a specific fusion method, the multimodal Source Power Co-modulation (mSPoC), to not only use functional but also anatomical information. The goal is to extract correlated source components from electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Anatomical information enters our proposed extension to mSPoC via the forward model, which relates the activity on cortex level to the EEG sensors. The augmented mSPoC is shown to outperform the original version in realistic simulations where the signal to noise ratio is low or where training epochs are scarce.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Berlin, Korea University
Authors: Hansen, S. T. (Intern), Winkler, I. (Ekstern), Hansen, L. K. (Intern), Müller, K. (Ekstern), Dahne, S. (Ekstern)
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Main Research Area: Technical/natural sciences
Geodesic exponential kernels: When Curvature and Linearity Conflict

We consider kernel methods on general geodesic metric spaces and provide both negative and positive results. First we show that the common Gaussian kernel can only be generalized to a positive definite kernel on a geodesic metric space if the space is flat. As a result, for data on a Riemannian manifold, the geodesic Gaussian kernel is only positive definite if the Riemannian manifold is Euclidean. This implies that any attempt to design geodesic Gaussian kernels on curved Riemannian manifolds is futile. However, we show that for spaces with conditionally negative definite distances the geodesic Laplacian kernel can be generalized while retaining positive definiteness. This implies that geodesic Laplacian kernels can be generalized to some curved spaces, including spheres and hyperbolic spaces. Our theoretical results are verified empirically.
Highly-Expressive Spaces of Well-Behaved Transformations: Keeping It Simple

We propose novel finite-dimensional spaces of $\mathbb{R}^n \to \mathbb{R}^n$ transformations, $n \in \{1, 2, 3\}$, derived from (continuously-defined) parametric stationary velocity fields. Particularly, we obtain these transformations, which are diffeomorphisms, by fast and highly-accurate integration of continuous piecewise-affine velocity fields; we also provide an ex-act solution for $n = 1$. The simple-yet-highly-expressive proposed representation handles optional constraints (e.g., volume preservation) easily and supports convenient modeling choices and rapid likelihood evaluations (facilitating tractable inference over latent transformations). Its applications include, but are not limited to: unconstrained optimization over monotonic functions; modeling cumulative distribution functions or histograms; time warping; image registration; landmark-based warping; real-time diffeomorphic image editing.

General information
State: Published
How Many Separable Sources? Model Selection In Independent Components Analysis

Unlike mixtures consisting solely of non-Gaussian sources, mixtures including two or more Gaussian components cannot be separated using standard independent components analysis methods that are based on higher order statistics and independent observations. The mixed Independent Components Analysis/Principal Components Analysis (mixed ICA/PCA) model described here accommodates one or more Gaussian components in the independent components analysis model and uses principal components analysis to characterize contributions from this inseparable Gaussian subspace. Information theory can then be used to select from among potential model categories with differing numbers of Gaussian components. Based on simulation studies, the assumptions and approximations underlying the Akaike Information Criterion do not hold in this setting, even with a very large number of observations. Cross-validation is a suitable, though computationally intensive alternative for model selection. Application of the algorithm is illustrated using Fisher's iris data set and Howells' craniometric data set. Mixed ICA/PCA is of potential interest in any field of scientific investigation where the authenticity of blindly separated non-Gaussian sources might otherwise be questionable. Failure of the Akaike Information Criterion in model selection also has relevance in traditional independent components analysis where all sources are assumed non-Gaussian.
Improving Semi-Supervised Learning with Auxiliary Deep Generative Models

Deep generative models based upon continuous variational distributions parameterized by deep networks give state-of-the-art performance. In this paper we propose a framework for extending the latent representation with extra auxiliary variables in order to make the variational distribution more expressive for semi-supervised learning. By utilizing the stochasticity of the auxiliary variable we demonstrate how to train discriminative classifiers resulting in state-of-the-art performance within semi-supervised learning exemplified by an 0.96% error on MNIST using 100 labeled data points. Furthermore we observe empirically that using auxiliary variables increases convergence speed suggesting that less expressive variational distributions, not only lead to looser bounds but also slower model training.
Investigating effects of different artefact types on motor imagery BCI

Artefacts in recordings of the electroencephalogram (EEG) are a common problem in Brain-Computer Interfaces (BCIs). Artefacts make it difficult to calibrate from training sessions, resulting in low test performance, or lead to artificially high performance when unintentionally used for BCI control. We investigate different artefacts' effects on motor-imagery based BCI relying on Common Spatial Patterns (CSP). Data stem from an 80-subject BCI study. We use the recently developed classifier IC_MARC to classify independent components of EEG data into neural and five classes of artefacts. We find that muscle, but not ocular, artefacts adversely affect BCI performance when all 119 EEG channels are used. Artefacts have little influence when using 48 centrally located EEG channels in a configuration previously found to be optimal.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technische Universität Berlin, Fraunhofer Heinrich Hertz Institute
Authors: Frølich, L. (Intern), Winkler, I. (Ekstern), Muller, K. (Ekstern), Samek, W. (Ekstern)
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Pages: 1942-1945
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Electronic versions: root_postprint.pdf
DOIs: 10.1109/EMBC.2015.7318764
Source: FindIt
Source-ID: 276544074
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Latent semantics of action verbs reflect phonetic parameters of intensity and emotional content

Conjuring up our thoughts, language reflects statistical patterns of word co-occurrences which in turn come to describe how we perceive the world. Whether counting how frequently nouns and verbs combine in Google search queries, or extracting eigenvectors from term document matrices made up of Wikipedia lines and Shakespeare plots, the resulting latent semantics capture not only the associative links which form concepts, but also spatial dimensions embedded within the surface structure of language. As both the shape and movements of objects have been found to be associated with phonetic contrasts already in toddlers, this study explores whether articulatory and acoustic parameters may likewise differentiate the latent semantics of action verbs. Selecting 3 X 20 emotion, face, and hand related verbs known to activate premotor areas in the brain, their mutual cosine similarities were computed using latent semantic analysis LSA, and the resulting adjacency matrices were compared based on two different large scale text corpora; HAWIK and TASA. Applying hierarchical clustering to identify common structures across the two text corpora, the verbs largely divide into combined mouth and hand movements versus emotional expressions. Transforming the verbs into their constituent phonemes, and projecting them into an articulatory space framed by tongue height and formant frequencies, the clustered small and large size movements appear differentiated by front versus back vowels corresponding to increasing levels of arousal. Whereas the clustered emotional verbs seem characterized by sequences of close versus open jaw produced phonemes, generating up- or downwards shifts in formant frequencies that may influence their perceived valence. Suggesting, that the latent semantics of action verbs reflect parameters of intensity and emotional polarity that appear correlated with the articulatory contrasts and acoustic characteristics of phonemes.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Petersen, M. K. (Intern)
Number of pages: 14
Learning Combinations of Multiple Feature Representations for Music Emotion Prediction

Music consists of several structures and patterns evolving through time which greatly influences the human decoding of higher-level cognitive aspects of music like the emotions expressed in music. For tasks, such as genre, tag and emotion recognition, these structures have often been identified and used as individual and non-temporal features and representations. In this work, we address the hypothesis whether using multiple temporal and non-temporal representations of different features is beneficial for modeling music structure with the aim to predict the emotions expressed in music. We test this hypothesis by representing temporal and non-temporal structures using generative models of multiple audio features. The representations are used in a discriminative setting via the Product Probability Kernel and the Gaussian Process model enabling Multiple Kernel Learning, finding optimized combinations of both features and temporal/ non-temporal representations. We show the increased predictive performance using the combination of different features and representations along with the great interpretive prospects of this approach.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Madsen, J. (Intern), Jensen, B. S. (Intern), Larsen, J. (Intern)
Pages: 3-8
Publication date: 2015

Mathematical model for biomolecular quantification using large-area surface-enhanced Raman spectroscopy mapping

Surface-enhanced Raman spectroscopy (SERS) based on nanostructured platforms is a promising technique for quantitative and highly sensitive detection of biomolecules in the field of analytical biochemistry. Here, we report a mathematical model to predict experimental SERS signal (or hotspot) intensity distributions of target molecules on receptor-functionalized nanopillar substrates for biomolecular quantification. We demonstrate that by utilizing only a small set of empirically determined parameters, our general theoretical framework agrees with the experimental data particularly well in the picomolar concentration regimes. This developed model may be generally used for biomolecular quantification using Raman mapping on SERS substrates with planar geometries, in which the hotspots are approximated as electromagnetic enhancement fields generated by closely spaced dimers. Lastly, we also show that the detection limit of a specific target molecule, TAMRA-labeled vasopressin, approaches the single molecule level, thus opening up an exciting new chapter in the field of SERS quantification.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Harvard University, Columbia University
Authors: Palla, M. (Ekstern), Bosco, F. (Intern), Yang, J. (Ekstern), Rindzevicius, T. (Intern), Alstrøm, T. S. (Intern), Schmidt, M. S. (Intern), Lin, Q. (Ekstern), Ju, J. (Ekstern), Boisen, A. (Intern)
Pages: 85845-85853
Publication date: 2015
Main Research Area: Technical/natural sciences
This paper presents the development of a novel statistical method for quantifying trace amounts of biomolecules by surface-enhanced Raman spectroscopy (SERS) using a rigorous, single molecule (SM) theory based mathematical derivation. Our quantification framework could be generalized for planar SERS substrates, in which the nanostructured features can be approximated as a closely spaced electromagnetic dimer problem. The potential for SM detection was also shown, which opens up an exciting opportunity in the field of SERS quantification.
Mobile Phones as Cognitive Systems
Driven by the ubiquitous availability of data and inexpensive data storage, our ability to sense human beings has increased dramatically. Big data has permeated the public discourse and led to surprising insights across the sciences and the humanities. This dissertation presents research on expanding our capabilities in collecting, handling, processing, and using data collected about human beings to create an integrated view of social systems. The goal of the thesis has been threefold.

The first part of the thesis focuses on the need, design, and implementation of large-scale sensor-driven human data collection studies. Social networks can be measured with high resolution and on multiple channels, such as face-to-face meetings, social networks, or phone calls, in order to generate a more comprehensive picture of social systems. The largest study to date measuring large-scale social system—the Copenhagen Networks Study—is described, together with motivation and challenges of the deployment. Preliminary results are presented, indicating how a possibly biased and incomplete picture can be generated when data are collected from a single channel and with a low resolution, thus emphasizing the importance of the proposed approach and deployed implementation.

The second part of the thesis deals with expanding our capabilities to sense the cognitive and emotional state of the users through development of a system for mobile brain imaging—the Smartphone Brain Scanner. A developed framework allows for EEG data collection and processing. It also provides the ability to build end-user applications on top of raw data and extracted features using off-the-shelf and custom-built neuroheadsets and mobile devices, thereby potentially becoming another channel in integrated human sensing. The motivation for creating such system is presented, advanced data processing—3D source reconstruction—is explained, and applications and use-cases are discussed.

In the third part, the privacy issues surrounding the handling of such sensitive behavioral and biomedical data are investigated. A comprehensive review of best privacy practices in sensor-driven human data collection is presented and recommendations for practitioners are made. Based on this review and experiences with the Copenhagen Networks Study and the Smartphone Brain Scanner, the concept of Living Informed Consent is presented, which postulates larger participant control over collected data for the benefit of users, researchers, and society at large. The same privacy principles are applied to a personal neuroinformatics context, resulting in a proposed new approach to sensitive EEG data handling.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Stopczynski, A. (Intern), Larsen, J. E. (Intern)
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Number: 336
ISSN: 0909-3192
Main Research Area: Technical/natural sciences
Electronic versions:
phd336_Stopczynski_A_web.pdf
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Modelling the structure of complex networks
A complex network is a systems in which a discrete set of units interact in a quantifiable manner. Representing systems as complex networks have become increasingly popular in a variety of scientific fields including biology, social sciences and economics. Parallel to this development complex networks has been independently studied as mathematical objects in their own right. As such, there has been both an increased demand for statistical methods for complex networks as well as a quickly growing mathematical literature on the subject.

In this dissertation we explore aspects of modelling complex networks from a probabilistic perspective. The first two chapter will be focused on the justification of the use of probabilistic methods for inference problems; we will look at the justification of probabilistic methods from the perspective of consistency and as a general method of updating beliefs. The next chapters will treat some of the various symmetries, representee theorems and probabilistic structures often deployed in the modelling complex networks, the construction of sampling methods and various network models.

The introductory chapters will serve to provide context for the included written work on the topics of (i) updating beliefs (ii) construction of samplers for partition-based problems (iii) applying non-parametric methods for modelling stationary and
temporal network data.

**General information**
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Herlau, T. (Intern), Mørup, M. (Intern)
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**Models and Modes of Audiovisual Integration**

**General information**
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Andersen, T. (Intern)
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**Relations**
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Models and Modes of Audiovisual integration
Publication: Research › Sound/Visual production (digital) – Annual report year: 2015

**Multiview Bayesian Correlated Component Analysis**
Correlated component analysis as proposed by Dmochowski, Sajda, Dias, and Parra (2012) is a tool for investigating brain process similarity in the responses to multiple views of a given stimulus. Correlated components are identified under the assumption that the involved spatial networks are identical. Here we propose a hierarchical probabilistic model that can infer the level of universality in such multiview data, from completely unrelated representations, corresponding to canonical correlation analysis, to identical representations as in correlated component analysis. This new model, which we denote Bayesian correlated component analysis, evaluates favorably against three relevant algorithms in simulated data. A well-established benchmark EEG data set is used to further validate the new model and infer the variability of spatial representations across multiple subjects.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Kamronn, S. D. (Intern), Poulsen, A. T. (Intern), Hansen, L. K. (Intern)
Pages: 2207-2230
Publication date: 2015
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Neural Computation
Volume: 27
New frontiers of quantified self: finding new ways for engaging users in collecting and using personal data

In spite of the fast growth in the market of devices and applications that allow people to collect personal information, Quantified Self (QS) tools still present a variety of issues when they are used in everyday lives of common people. In this workshop we aim at exploring new ways for designing QS systems, by gathering different researchers in a unique place for imagining how the tracking, management, interpretation and visualization of personal data could be addressed in the future.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Torino, University of Sydney, University of Glasgow, Technische Universität Berlin
Authors: Rapp, A. (Ekstern), Cena, F. (Ekstern), Kay, J. (Ekstern), Kummerfeld, B. (Ekstern), Hopfgartner, F. (Ekstern), Plumbaum, T. (Ekstern), Larsen, J. E. (Intern)
Pages: 969-972
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Main Research Area: Technical/natural sciences
DOIs: 10.1145/2800835.2807947
Source: PublicationPreSubmission
Source-ID: 118365193
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Nonparametric modeling of dynamic functional connectivity in fMRI data
Dynamic functional connectivity (FC) has in recent years become a topic of interest in the neuroimaging community. Several models and methods exist for both functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), and the results point towards the conclusion that FC exhibits dynamic changes. The existing approaches modeling dynamic connectivity have primarily been based on time-windowing the data and k-means clustering. We propose a nonparametric generative model for dynamic FC in fMRI that does not rely on specifying window lengths and number of dynamic states. Rooted in Bayesian statistical modeling we use the predictive likelihood to investigate if the model can discriminate between a motor task and rest both within and across subjects. We further investigate what drives dynamic states using the model on the entire data collated across subjects and task/rest. We find that the number of states extracted are driven by subject variability and preprocessing differences while the individual states are almost purely defined by either task or rest. This questions how we in general interpret dynamic FC and points to the need for more research on what drives dynamic FC.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital
Authors: Nielsen, S. F. V. (Intern), Madsen, K. H. (Ekstern), Røge, R. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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Workshop: 5th NIPS Workshop on Machine Learning and Interpretation in Neuroimaging (MLINI 2015), Montreal, Quebec, Canada, 11/12/2015 - 11/12/2015
Dynamic functional connectivity, Bayesian nonparametric modeling, Hidden Markov modeling, Wishart mixture modeling, Predictive likelihood
Electronic versions: nielsen2015mlini_1.pdf
Source: PublicationPreSubmission
Source-ID: 117991839
Numerical approximations for speeding up MCMC inference in the infinite relational model

The infinite relational model (IRM) is a powerful model for discovering clusters in complex networks; however, the computational speed of Markov chain Monte Carlo inference in the model can be a limiting factor when analyzing large networks. We investigate how using numerical approximations of the log-Gamma function in evaluating the likelihood of the IRM can improve the computational speed of MCMC inference, and how it affects the performance of the model. Using an ensemble of networks generated from the IRM, we compare three approximations in terms of their generalization performance measured on test data. We demonstrate that the computational time for MCMC inference can be reduced by a factor of two without affecting the performance, making it worthwhile in practical situations when on a computational budget.

On Geodesic Exponential Kernels

This extended abstract summarizes work presented at CVPR 2015 [1].

Standard statistics and machine learning tools require input data residing in a Euclidean space. However, many types of data are more faithfully represented in general nonlinear metric spaces or Riemannian manifolds, e.g. shapes, symmetric positive definite matrices, human poses or graphs. The underlying metric space captures domain specific knowledge, e.g. non-linear constraints, which is available a priori. The intrinsic geodesic metric encodes this knowledge, often leading to improved statistical models.
Online Open Neuroimaging Mass Meta-Analysis with a Wiki

We describe a system for meta-analysis where a wiki stores numerical data in a simple comma-separated values format and a web service performs the numerical statistical computation. We initially apply the system on multiple meta-analyses of structural neuroimaging data results. The described system allows for mass meta-analysis, e.g., meta-analysis across multiple brain regions and multiple mental disorders providing an overview of important relationships and their uncertainties in a collaborative environment.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, King's College London
Authors: Nielsen, F. A. (Intern), Kempton, M. J. (Ekstern), Williams, S. C. R. (Ekstern)
Pages: 259-271
Publication date: 2015

Opportunities and Challenges in Crowdsourced Wardriving

Knowing the physical location of a mobile device is crucial for a number of context-aware applications. This information is usually obtained using the Global Positioning System (GPS), or by calculating the position based on proximity of WiFi access points with known location (where the position of the access points is stored in a database at a central server). To date, most of the research regarding the creation of such a database has investigated datasets collected both artificially and over short periods of time (e.g., during a one-day drive around a city). In contrast, most in-use databases are collected by mobile devices automatically, and are maintained by large mobile OS providers.

As a result, the research community has a poor understanding of the challenges in creating and using large-scale WiFi localization databases. We address this situation using the deployment of over 800 mobile devices to real users over a 1.5 year period. Each device periodically records WiFi scans and its GPS coordinates, reporting the collected data to us. We identify a number of challenges in using such data to build a WiFi localization database (e.g., mobility of access points), and introduce techniques to mitigate them. We also explore the level of coverage needed to accurately estimate a user’s location, showing that only a small subset of the database is needed to achieve high accuracy.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Northeastern University
Authors: Sapiezynski, P. (Intern), Gatej, R. (Ekstern), Mislove, A. (Ekstern), Jørgensen, S. L. (Intern)
Pages: 267-273
Patterns of trawling exploitation and the occurrence of hypoxia in the Baltic Sea

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Swedish University of Agricultural Sciences
Authors: Bartolino, V. (Ekstern), Guillot, G. (Intern)
Number of pages: 9
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Main Research Area: Technical/natural sciences

Bibliographical note
This is a CONFIDENTIAL research report

Perception-Based Personalization of Hearing Aids Using Gaussian Processes and Active Learning

Personalization of multi-parameter hearing aids involves an initial fitting followed by a manual knowledge-based trial-and-error fine-tuning from ambiguous verbal user feedback. The result is an often suboptimal HA setting whereby the full potential of modern hearing aids is not utilized. This article proposes an interactive hearing-aid personalization system that obtains an optimal individual setting of the hearing aids from direct perceptual user feedback. Results obtained with ten hearing-impaired subjects show that ten to twenty pairwise user assessments between different settings—equivalent to 5-10 min—is sufficient for personalization of up to four hearing-aid parameters. A setting obtained by the system was significantly preferred by the subject over the initial fitting, and the obtained setting could be reproduced with reasonable precision. The system may have potential for clinical usage to assist both the hearing-care professional and the user.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Widex A/S
Authors: Nielsen, J. B. (Intern), Nielsen, J. (Intern), Larsen, J. (Intern)
Pages: 162-173
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Main Research Area: Technical/natural sciences

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Journal: IEEE/ACM Transactions on Audio, Speech, and Language Processing
Volume: 23
Issue number: 1
ISSN (Print): 2329-9290
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 4.2 SJR 0.867
Principal Curves on Riemannian Manifolds

Euclidean statistics are often generalized to Riemannian manifolds by replacing straight-line interpolations with geodesic ones. While these Riemannian models are familiar-looking, they are restricted by the inflexibility of geodesics, and they rely on constructions which are optimal only in Euclidean domains. We consider extensions of Principal Component Analysis (PCA) to Riemannian manifolds. Classic Riemannian approaches seek a geodesic curve passing through the mean that optimize a criteria of interest. The requirements that the solution both is geodesic and must pass through the mean tend to imply that the methods only work well when the manifold is mostly flat within the support of the generating distribution. We argue that instead of generalizing linear Euclidean models, it is more fruitful to generalize non-linear Euclidean models. Specifically, we extend the classic Principal Curves from Hastie & Stuetzle to data residing on a complete Riemannian manifold. We show that for elliptical distributions in the tangent of spaces of constant curvature, the standard principal geodesic is a principal curve. The proposed model is simple to compute and avoids many of the pitfalls of traditional geodesic approaches. We empirically demonstrate the effectiveness of the Riemannian principal curves on several manifolds and datasets.
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Scopus rating (2017): SNIP 6.357 SJR 2.367
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 13.29 SJR 5.388 SNIP 6.403
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.475 SNIP 7.634 CiteScore 11.05
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.301 SNIP 8.052 CiteScore 11.8
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.874 SNIP 8.948 CiteScore 10.09
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.508 SNIP 7.15 CiteScore 8.89
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.634 SNIP 7.144
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.536 SNIP 6.521
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.979 SNIP 7.128
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.815 SNIP 6.645
Scopus rating (2005): SJR 3.039 SNIP 7.643
Scopus rating (2004): SJR 2.21 SNIP 6.556
Scopus rating (2003): SJR 4.208 SNIP 7.434
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.306 SNIP 5.478
Web of Science (2002): Indexed yes
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Scopus rating (2000): SJR 1.593 SNIP 3.488
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Electronic versions:
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Source: PublicationPreSubmission
Rare disease diagnosis: A review of web search, social media and large-scale data-mining approaches

Physicians and the general public are increasingly using web-based tools to find answers to medical questions. The field of rare diseases is especially challenging and important as shown by the long delay and many mistakes associated with diagnoses. In this paper we review recent initiatives on the use of web search, social media and data mining in data repositories for medical diagnosis. We compare the retrieval accuracy on 56 rare disease cases with known diagnosis for the web search tools google.com, pubmed.gov, omim.org and our own search tool findzebra.com. We give a detailed description of IBM's Watson system and make a rough comparison between findzebra.com and Watson on subsets of the Doctor's dilemma dataset. The recall@10 and recall@20 (fraction of cases where the correct result appears in top 10 and top 20) for the 56 cases are found to be be 29%, 16%, 27% and 59% and 32%, 18%, 34% and 64%, respectively. Thus, FindZebra has a significantly (p <0.01) higher recall than the other 3 search engines. When tested under the same conditions, Watson and FindZebra showed similar recall@10 accuracy. However, the tests were performed on different subsets of Doctors dilemma questions. Advances in technology and access to high quality data have opened new possibilities for aiding the diagnostic process. Specialized search engines, data mining tools and social media are some of the areas that hold promise.
Robustness and modular structure in networks

Complex networks have recently attracted much interest due to their prevalence in nature and our daily lives [1, 2]. A critical property of a network is its resilience to random breakdown and failure [3-6], typically studied as a percolation problem [7-9] or by modeling cascading failures[10-12]. Many complex systems, from power grids and the Internet to the brain and society [13-15], can be modeled using modular networks comprised of small, densely connected groups of nodes [16, 17]. These modules often overlap, with network elements belonging to multiple modules [18, 19]. Yet existing work on robustness has not considered the role of overlapping, modular structure. Here we study the robustness of these systems to the failure of elements. We show analytically and empirically that it is possible for the modules themselves to become uncoupled or non-overlapping well before the network disintegrates. If overlapping modular organization plays a role in overall functionality, networks may be far more vulnerable than predicted by conventional percolation theory.

Role of emotional processing in depressive responses to sex-hormone manipulation: a pharmacological fMRI study

Sex-hormone fluctuations may increase risk for developing depressive symptoms and alter emotional processing as supported by observations in menopausal and pre- to postpartum transition. In this double-blinded, placebo-controlled study, we used blood-oxygen level dependent functional magnetic resonance imaging (fMRI) to investigate if sex-steroid hormone manipulation with a gonadotropin-releasing hormone agonist (GnRHa) influences emotional processing. Fifty-six
Healthy women were investigated twice: at baseline (follicular phase of menstrual cycle) and 16 +/- 3 days post intervention. At both sessions, fMRI-scans during exposure to faces expressing fear, anger, happiness or no emotion, depressive symptom scores and estradiol levels were acquired. The fMRI analyses focused on regions of interest for emotional processing. As expected, GnRHa initially increased and subsequently reduced estradiol to menopausal levels, which was accompanied by an increase in subclinical depressive symptoms relative to placebo. Women who displayed larger GnRHa-induced increase in depressive symptoms had a larger increase in both negative and positive emotion-elicited activity in the anterior insula. When considering the post-GnRHa scan only, depressive responses were associated with emotion-elicited activity in the anterior insula and amygdala. The effect on regional activity in anterior insula was not associated with the estradiol net decline, only by the GnRHa-induced changes in mood. Our data implicate enhanced insula recruitment during emotional processing in the emergence of depressive symptoms following sex-hormone fluctuations. This may correspond to the emotional hypersensitivity frequently experienced by women postpartum.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital
Authors: Henningsson, S. (Ekstern), Madsen, K. H. (Intern), Pinborg, A. (Ekstern), Heede, M. (Ekstern), Knudsen, G. M. (Ekstern), Siebner, H. R. (Ekstern), Frokjaer, V. G. (Ekstern)
Pages: 1-8
Publication date: 2015
Main Research Area: Technical/natural sciences

S-AMP for non-linear observation models
Recently we presented the S-AMP approach, an extension of approximate message passing (AMP), to be able to handle general invariant matrix ensembles. In this contribution we extend S-AMP to non-linear observation models. We obtain generalized AMP (GAMP) as the special case when the measurement matrix has zero-mean iid Gaussian entries. Our derivation is based upon 1) deriving expectation-propagation-(EP)-like equations from the stationary-points equations of the Gibbs free energy under first- and second-moment constraints and 2) applying additive free convolution in free probability theory to get low-complexity updates for the second moment quantities.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Applied Mathematics and Computer Science, Cognitive Systems, Aalborg University
Authors: Cakmak, B. (Ekstern), Winther, O. (Intern), Fleury, B. H. (Ekstern)
Self-Disorder and Brain Processing of Proprioception in Schizophrenia Spectrum Patients: A Re-Analysis

Background: Anomalies of self-awareness (self-disorders, SDs) are theorized to be basic to schizophrenia psychopathology. We have previously observed dysfunction of brain processing of proprioception in schizophrenia spectrum disorders (SZS). We hypothesized that SDs could be associated with abnormalities of early contralateral proprioceptive evoked oscillatory brain activity. Methods: We investigated the association between proprioceptive evoked potential components and SDs in a re-analysis of data from a subsample (n = 12) of SZS patients who had previously been observed with deviant proprioceptive evoked potentials and interviewed with the Examination of Anomalous Self-Experience (EASE) scale. Results: Higher EASE scores (i.e. increased SD) were associated with lower peak parietal gamma frequencies and higher peak beta amplitudes over frontal and parietal electrodes in the left hemisphere following right-hand proprioceptive stimulation. Conclusion: Disorders of self-awareness may be associated with dysfunction of early phases of somatosensory processing. The findings are potentially relevant to our understanding of the pathophysiology of schizophrenia, but further studies are needed.
SOA thresholds for the perception of discrete/continuous tactile stimulation

In this paper we present an experiment to measure the upper and lower thresholds of the Stimulus Onset Asynchrony (SOA) for continuous/discrete apparent haptic motion. We focus on three stimulation parameters: the burst duration, the SOA time, and the inter-actuator distance (between successive actuation points). The experimental setup is based on a set of six (6) vibrotactile actuators to investigate effects of the inter-actuator distance (over the range 4 cm to 20 cm) on the respective SOA thresholds. We found that as the burst duration increases, subjects detected the simultaneous-discrete boundary at lower SOA. Furthermore, the larger the inter-actuator distance, the more linear the relationship between the burst duration and the SOA timing. Finally, the large range between lower and upper thresholds for SOA can be utilized to create continuous movement stimulation on the skin at "varying speeds". The results are discussed in reference to designing a tactile interface for providing continuous haptic motion with a desired speed of continuous tactile stimulation.

General information
State: Published
Authors: Eid, M. (Ekstern), Korres, G. (Ekstern), Jensen, C. B. F. (Intern)
Number of pages: 6
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Main Research Area: Technical/natural sciences
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Statistical analysis of large areas of Raman mapped DNA functionalized gold coated silicon nanopillar SERS substrates

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Surface Engineering, Department of Applied Mathematics and Computer Science, Cognitive Systems, Nanoprobes
Statistical learning for predictive targeting in online advertising

The focus in this thesis is investigation of machine learning methods with applications in computational advertising. Computational advertising is the broad discipline of building systems which can reach audiences browsing the Internet with targeted advertisements. At the core of such systems, algorithms are needed for making decisions. It is in one such particular instance of computational advertising, namely in web banner advertising, that we investigate machine learning methods to assist and make decisions in order to optimize the placements of ads.

The industrial partner in this work is Adform, an international online advertising technology partner. This also means that the analyses and methods in this work are developed with particular use-cases within Adform in mind and thus need also to be applicable in Adform’s technology stack. This implies extra thought on scalability and performance.

The particular use-case which is used as a benchmark for our results, is clickthrough rate prediction. In this task one aims to predict the probability that a user will click on an advertisement, based on attributes about the user, the advertisement the context, and other signals, such as time. This has its main application in real-time bidding ad exchanges, where each advertiser is given a chance to place bids for showing their ad while the page loads, and the winning bid gets to display their banner.

The contributions of this thesis entail application of a hybrid model of explicit and latent features for learning probabilities of clicks, which is a methodological extension of the current model in production at Adform. Our findings confirm that latent features can increase predictive performance in the setup of click-through rate prediction. They also reveal a tedious process for tuning the model for optimal performance.

We also present variations of Bayesian generative models for stochastic blockmodeling for inference of structure based on browsing patterns. Applying this structural information to improve click-through rate prediction becomes a two-step procedure: 1) learn user and URL profiles from browsing patterns, 2) use the profiles as additional features in a click-through rate prediction model. The assumption we implicitly make is reasonable: Users and URLs that are grouped together based on browsing patterns will have similar responses to ads, e.g., can be used as predictors of clicks. We report successful examples of applying this approach in practice.

Finally, we introduce the multiple-networks stochastic blockmodel (MNSBM), a model for efficient overlapping community detection in complex networks which can be assumed to be an aggregation of multiple block-structured subnetworks.
Synchronised and complementary coordination mechanisms in an asymmetric joint aiming task

Many forms of social interaction require that behaviour be coordinated in the here and now. Much research has been conducted on how people coordinate their actions in real time to achieve a joint goal, showing that people use both synchronised (i.e. symmetric) and complementary (i.e. asymmetric) strategies. These two mechanisms have been mostly studied independently, the former in the context of rhythmic tasks, and the latter in non-rhythmic tasks. However, people often balance these two strategies in real life social interactions, in order to achieve a joint goal more effectively. Here, our aim was to investigate how people may implicitly balance synchronisation and complementarity in a continuous joint aiming task.

We asked dyads to synchronise the timing of their clicks between targets, while changing task constraints for one member of the dyad (i.e. different task difficulties) to asymmetrically perturb the continuous interaction. This allowed us to investigate how individuals implicitly negotiate complementary leader-follower dynamics to achieve synchronisation. We found that dyads flexibly switch from mutual to asymmetric adaptation given variations in task constraints. Specifically, our results show that both members adapt equally up to a certain level of difficulty; after this point, the partner with the difficult task becomes less adaptive, and hence more of a leader, while the adaptability of the member with the easier task remains unchanged. This proves to be an effective strategy in this asymmetric task, as people synchronise better with an irregular, but adaptive partner, than with a completely predictable, but non-responsive metronome. These results show that given asymmetric task constraints, adaptability, rather than predictability facilitates coordination.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Central European University, Aarhus University, University of Copenhagen
Authors: Skewes, J. C. (Ekstern), Skewes, L. (Ekstern), Michael, J. (Ekstern), Konvalinka, I. (Intern)
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Scopus rating (2016): CiteScore 1.97 SJR 0.99 SNIP 0.818
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.161 SNIP 0.879 CiteScore 2.08
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Web of Science (2011): Indexed yes
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Scopus rating (2010): SJR 1.33 SNIP 1.03
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Systems for Personalization of Hearing Instruments: A Machine Learning Approach

Today, modern digital devices can be customized significantly to the individual user by adjusting or optimizing multiple parameters affecting the output of the devices. Such personal optimization of devices is referred to as personalization. In the case of hearing aids, personalization is not only a possibility offered to the user, but a requirement that must be performed carefully and precisely in order for the user to utilize the full potential of modern multi-parameter hearing aids. Today though, personalization is still based on a manual timeconsuming trial-and-error approach performed by the user himself or, in case of hearing aids, by a hearing-care professional based on typically ambiguous oral feedback from the user. This often results in sub-optimal or even inappropriate settings of multi-parameter devices. This dissertation presents research on a machine-learning based interactive personalization system to improve the personalization of devices and, in particular, of hearing-aid devices. The proposed personalization system iteratively learns a non-parametric probabilistic model of a user’s assumed internal response function over all possible settings of a multi-parameter device based directly on sequential perceptual feedback from the user. A sequential design based on active learning is used to obtain the maximum of the user’s unknown internal response function in as few iterations as possible. Experiments were conducted where the proposed personalization system obtained a significantly preferred setting for individual users within ten to twenty iterations in scenarios with up to four parameters.

Following a short introduction that includes a summary of results and contributions, the first main chapter focuses on the probabilistic modeling framework in which a Gaussian process is used to model the user’s unobserved internal response function. The first main challenge addressed in this context is to account for inconsistent and thus noisy user feedback. The second main challenge addressed is to support feedback which closely reflects the user’s perception while providing maximal information about it without imposing a high cognitive load. In the second main chapter, active learning and sequential design are discussed in relation to the challenge of obtaining the setting that maximizes the user’s unobserved internal response function in as few iterations as possible. For the Gaussian process framework, an active learning criterion is proposed specifically suitable for this type of optimization. The final chapter contains an overall discussion and conclusion of the present work and research based in part on the results from eight scientific paper contributions contained in the appendices.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Widex A/S
Authors: Nielsen, J. B. (Intern), Larsen, J. (Intern), Nielsen, J. (Ekstern)
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Temporal fidelity in dynamic social networks

It has recently become possible to record detailed social interactions in large social systems with high resolution. As we study these datasets, human social interactions display patterns that emerge at multiple time scales, from minutes to months. On a fundamental level, understanding of the network dynamics can be used to inform the process of measuring social networks. The details of measurement are of particular importance when considering dynamic processes where minute-to-minute details are important, because collection of physical proximity interactions with high temporal resolution is difficult and expensive. Here, we consider the dynamic network of proximity-interactions between approximately 500 individuals participating in the Copenhagen Networks Study. We show that in order to accurately model spreading processes in the network, the dynamic processes that occur on the order of minutes are essential and must be included in the analysis.

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Testing Multimodal Integration Hypotheses with Application to Schizophrenia Data
Multimodal data sets are getting more and more common. Integrating these data sets, the information from each modality can be combined to improve performance in classification problems. Fusion/integration of modalities can be done at several levels. The most appropriate fusion level is related to the conditional dependency between modalities. A varying degree of inter-modality dependency can be present across the modalities. A method for assessing the conditional dependency structure of the modalities and their relationship to intra-modality dependencies in each modality is therefore needed. The aim of the present paper is to propose a method for assessing these inter-modality dependencies. The approach is based on two permutations of an analyzed data set, each exploring different dependencies between and within modalities. The method was tested on the Kaggle MLSP 2014 Schizophrenia Classification Challenge data set which is composed of features from functional magnetic resonance imaging (MRI) and structural MRI. The results support the use of a permutation strategy for testing conditional dependencies between modalities in a multimodal classification problem.
The Danish 22q11 research initiative

Background: Neurodevelopmental brain disorders such as schizophrenia, autism and attention deficit hyperactivity disorder are complex disorders with heterogeneous etiologies. Schizophrenia and autism are difficult to treat and often cause major individual suffering largely owing to our limited understanding of the disease biology. Thus our understanding of the biological pathogenesis needs to be substantiated to enable development of more targeted treatment options with improved efficacy. Insights into the pre-morbid disease dynamics, the morbid condition and the underlying biological disease mechanisms may come from studies of subjects with homogenous etiologies. Breakthroughs in psychiatric genetics have shown that several genetic anomalies predispose for neurodevelopmental brain disorders. We have established a Danish research initiative to study the common microdeletion at chromosome 22q11.2, which is one of the genetic anomalies that confer high risk of schizophrenia, autism and attention deficit hyperactivity disorder.

Methods/design: The study applies a "cause-to-outcome" strategy to identify pre-morbid pathogenesis and underlying biological disease mechanisms of psychosis and secondarily the morbid condition of autism and attention deficit hyperactivity disorder. We use a population based epidemiological design to inform on disease prevalence, environmental risk factors and familial disposition for mental health disorders and a case control study design to map the functional effects across behavioral and neurophysiological traits of the 22q11 deletion in a recruited sample of Danish individuals.

Discussion: Identification of predictive pre-morbid clinical, cognitive, functional and structural brain alterations in 22q11 deletion carriers may alter current clinical practice from symptomatic therapy of manifest mental illness into early intervention strategies, which may also be applicable to at risk subjects without known etiology. Hopefully new insights into the biological disease mechanisms, which are mandatory for novel drug developments, can improve the outcome of the pharmacological interventions in psychiatry.

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Web of Science (2015): Indexed yes
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BFI (2013): BFI-level 2
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The early maximum likelihood estimation model of audiovisual integration in speech perception

Speech perception is facilitated by seeing the articulatory mouth movements of the talker. This is due to perceptual audiovisual integration, which also causes the McGurk–MacDonald illusion, and for which a comprehensive computational account is still lacking. Decades of research have largely focused on the fuzzy logical model of perception (FLMP), which provides excellent fits to experimental observations but also has been criticized for being too flexible, post hoc and difficult to interpret. The current study introduces the early maximum likelihood estimation (MLE) model of audiovisual integration to speech perception along with three model variations. In early MLE, integration is based on a continuous internal representation before categorization, which can make the model more parsimonious by imposing constraints that reflect experimental designs. The study also shows that cross-validation can evaluate models of audiovisual integration based on typical data sets taking both goodness-of-fit and model flexibility into account. All models were tested on a published data set previously used for testing the FLMP. Cross-validation favored the early MLE while more conventional error measures favored more complex models. This difference between conventional error measures and cross-validation was found to be indicative of over-fitting in more complex models such as the FLMP.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Andersen, T. (Intern)
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Wikipedia may be the best-developed attempt thus far to gather all human knowledge in one place. Its accomplishments in this regard have made it a point of inquiry for researchers from different fields of knowledge. A decade of research has thrown light on many aspects of the Wikipedia community, its processes, and its content. However, due to the variety of fields inquiring about Wikipedia and the limited synthesis of the extensive research, there is little consensus on many aspects of Wikipedia's content as an encyclopedic collection of human knowledge. This study addresses the issue by systematically reviewing 110 peer-reviewed publications on Wikipedia content, summarizing the current findings, and highlighting the major research trends. Two major streams of research are identified: the quality of Wikipedia content (including comprehensiveness, currency, readability, and reliability) and the size of Wikipedia. Moreover, we present the key research trends in terms of the domains of inquiry, research design, data source, and data gathering methods. This review synthesizes scholarly understanding of Wikipedia content and paves the way for future studies.
Thinking outside of the box or enjoying your 2 seconds of frame?
The emergence of low cost eye tracking devices will make QS quantified self monitoring of eye movements attainable on next generation mobile devices, potentially allowing us to infer reactions related to fatigue or emotional responses on a continuous basis when interacting with the screens of smartphones and tablets. In the current study we explore whether consumer grade eye trackers, despite their reduced spatio-temporal resolution, are able to monitor fixations as well as frequencies of saccades and blinks that may characterize aspects of attention, and identify consistent individual patterns that may be modulated by our overall level of engagement.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Bækgaard, P. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern)
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Topological Rankings in Communication Networks

In the theory of communication the central problem is to study how agents exchange information. This problem may be studied using the theory of connected spaces in topology, since a communication network can be modelled as a topological space such that agents can communicate if and only if they belong to the same path connected component of that space. In order to study combinatorial properties of such a communication network, notions from algebraic topology are applied. This makes it possible to determine the shape of a network by concrete invariants, e.g. the number of connected components. Elements of a network may then be ranked according to how essential their positions are in the network by considering the effect of removing them. Defining a ranking of a network which takes the individual position of each entity into account has the purpose of assigning different roles to the entities, e.g. agents, in the network. In this paper it is shown that the topology of a given network induces a ranking of the entities in the network. Furthermore, it is demonstrated how to calculate this ranking and thus how to identify weak sub-networks in any given network.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy resources, services and control, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Aabrandt, A. (Intern), Hansen, V. L. (Intern), Traeholt, C. (Intern)
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Scopus rating (2011): SJR 0.11 SNIP 0.14 CiteScore 0.09
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Towards quantitative SERS detection of hydrogen cyanide at ppb level for human breath analysis

Lung infections with Pseudomonas aeruginosa (PA) is the most common cause of morbidity and mortality in cystic fibrosis (CF) patients. Due to its ready adaptation to the dehydrated mucosa of CF airways, PA infections tend to become chronic, eventually killing the patient. Hydrogen cyanide (HCN) at ppb level has been reported to be a PA biomarker. For early PA detection in CF children not yet chronically lung infected a non-invasive Surface-Enhanced Raman Spectroscopy (SERS)-based breath nanosensor is being developed. The triple bond between C and N in cyanide, with its characteristic band at ~2133 cm$^{-1}$, is an excellent case for the SERS-based detection due to the infrequent occurrence of triple bonds in nature.
For demonstration of direct HCN detection in the gas phase, a gold-coated silicon nanopillar substrate was exposed to 5 ppm HCN in N2. Results showed that HCN adsorbed on the SERS substrate can be consistently detected under different experimental conditions and up to 9 days after exposure. For detection of lower cyanide concentrations serial dilution experiments using potassium cyanide (KCN) demonstrated cyanide quantification down to 1 μM in solution (corresponding to 18 ppb). Lower KCN concentrations of 10 and 100 nM (corresponding to 0.18 and 1.8 ppb) produced SERS intensities that were relatively similar to the reference signal. Since HCN concentration in the breath of PA colonized CF children is reported to be ~13.5 ppb, the detection of cyanide is within the required range.

**General information**

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**Organisations:** Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factories, Department of Chemistry, Department of Applied Mathematics and Computer Science, Cognitive Systems, Amphiphilic Polymers in Biological Sensing, Department of Environmental Engineering, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics  
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**Tracking Human Mobility Using WiFi Signals**

We study six months of human mobility data, including WiFi and GPS traces recorded with high temporal resolution, and find that time series of WiFi scans contain a strong latent location signal. In fact, due to inherent stability and low entropy of human mobility, it is possible to assign location to WiFi access points based on a very small number of GPS samples and then use these access points as location beacons. Using just one GPS observation per day per person allows us to estimate the location of, and subsequently use, WiFi access points to account for 80% of mobility across a population. These results reveal a great opportunity for using ubiquitous WiFi routers for high-resolution outdoor positioning, but also significant privacy implications of such side-channel location tracking.

**General information**

**State:** Published  
**Organisations:** Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen  
**Authors:** Sapiezynski, P. (Intern), Stopczynski, A. (Intern), Gatej, R. (Ekstern), Jørgensen, S. L. (Intern)  
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**Main Research Area:** Technical/natural sciences

**Publication information**

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Transcranial Magnetic Stimulation: An Automated Procedure to Obtain Coil-specific Models for Field Calculations

**Background:** Field calculations for transcranial magnetic stimulation (TMS) are increasingly implemented online in neuronavigation systems and in more realistic offline approaches based on finite-element methods. They are often based
on simplified and/or non-validated models of the magnetic vector potential of the TMS coils.

**Objective:** To develop an approach to reconstruct the magnetic vector potential based on automated measurements.

**Methods:** We implemented a setup that simultaneously measures the three components of the magnetic field with high spatial resolution. This is complemented by a novel approach to determine the magnetic vector potential via volume integration of the measured field.

**Results:** The integration approach reproduces the vector potential with very good accuracy. The vector potential distribution of a standard figure-of-eight shaped coil determined with our setup corresponds well with that calculated using a model reconstructed from x-ray images.

**Conclusion:** The setup can supply validated models for existing and newly appearing TMS coils.

**General information**

State: Published

Organisations: Department of Informatics and Mathematical Modeling, Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Electrical Engineering, Center for Magnetic Resonance, Copenhagen University Hospital

Authors: Madsen, K. H. (Intern), Ewald, L. (Ekstern), Siebner, H. R. (Ekstern), Thielscher, A. (Intern)

Pages: 1205-1208

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Main Research Area: Technical/natural sciences
Tumor suppressor ASXL1 is essential for the activation of INK4B expression in response to oncogene activity and anti-proliferative signals

ASXL1 mutations are frequently found in hematological tumors, and loss of Asxl1 promotes myeloid transformation in mice. Here we present data supporting a role for an ASXL1-BAP1 complex in the deubiquitylation of mono-ubiquitylated lysine 119 on Histone H2A (H2AK119ub1) in vivo. The Polycomb group proteins control the expression of the INK4B-ARF-INK4A locus during normal development, in part through catalyzing mono-ubiquitylation of H2AK119. Since the activation of the locus INK4B-ARF-INK4A plays a fail-safe mechanism protecting against tumorigenesis, we investigated whether ASXL1-dependent H2A deubiquitylation plays a role in its activation. Interestingly, we found that ASXL1 is specifically required for the increased expression of p15(INK4B) in response to both oncogenic signaling and extrinsic anti-proliferative signals. Since we found that ASXL1 and BAP1 both are enriched at the INK4B locus, our results suggest that activation of the INK4B locus requires ASXL1/BAP1-mediated deubiquitylation of H2AK119ub1. Consistently, our results show that ASXL1 mutations are associated with lower expression levels of p15(INK4B) and a proliferative advantage of hematopoietic progenitors in primary bone marrow cells, and that depletion of ASXL1 in multiple cell lines results in resistance to growth inhibitory signals. Taken together, this study links ASXL1-mediated H2A deubiquitylation and transcriptional activation of INK4B expression to its tumor suppressor functions.
Unsupervised segmentation of task activated regions in fMRI

Functional Magnetic Resonance Imaging has become a central measuring modality to quantify functional activation of the brain in both task and rest. Most analysis used to quantify functional activation requires supervised approaches as employed in statistical parametric mapping (SPM) to extract maps of task induced functional activations. This requires strong knowledge and assumptions on the BOLD response as a function of activation while smoothing in general enhances the statistical power but at the cost of spatial resolution. We propose a fully unsupervised approach for the extraction of task activated functional units in multi-subject fMRI data that exploits that regions of task activation are consistent across subjects and can be more reliably inferred than regions that are not activated. We develop a non-parametric Gaussian mixture model that a priori assumes activations are smooth using a Gaussian Process prior while assuming the segmented functional maps are the same across subjects but having individual time-courses and noise variances. To improve inference we propose an enhanced split-merge procedure. We find that our approach well extracts the induced activity of a finger tapping fMRI paradigm with maps that well corresponds to a supervised group SPM analysis. We further find interesting regions that are not activated time locked to the paradigm. Demonstrating that we in a fully unsupervised manner are able to extract the task-induced activations forms a promising framework for the analysis of task fMRI and resting-state data in general where strong knowledge of how the task induces a BOLD response is missing.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Danish Research Centre for Magnetic Resonance
Authors: Røge, R. (Intern), Madsen, K. H. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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Publisher: IEEE
Main Research Area: Technical/natural sciences

Variation in adaptive resilience underscores differences in vulnerability to a changing environment for an ecologically important freshwater fish species

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Flinders University, University of Canberra, Universite Laval
Authors: Smith, S. (Ekstern), Brauer, C. (Ekstern), Unmack, P. (Ekstern), Guillot, G. (Intern), Bernatchez, L. (Ekstern), B. Beheregaray, L. (Ekstern)
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Original language: English
Main Research Area: Technical/natural sciences
Vibration-based SHM System: Application to Wind Turbine Blades

This study presents an vibration-based system designed for structural health monitoring of wind turbine blades. Mechanical energy is introduced by means of an electromechanical actuator mounted inside the blade. The actuator's plunger periodically hits the blade structure; the induced vibrations propagate along the blade and are measured by an array of accelerometers. Unsupervised learning is applied to the data: the vibration patterns corresponding to the undamaged blade are used to create a statistical model of the reference state. During the detection stage, the current vibration pattern is compared with the reference state, and the novelties can be associated with damage. The vibration pattern is described by the covariance matrix between the accelerometer signals. The mid-range frequencies are used: this range is above the frequencies excited by blade-wind interaction, thus ensuring a good signal-to-noise ratio. Simultaneously, the frequencies are low enough to be able to propagate the entire blade length, so good results can be obtained even using only one actuator. The system is demonstrated on a real 34m blade mounted on a test rig. Using the suggested approach, the system enables detection of, e.g., a 20cm long trailing edge opening under realistic noise conditions. It is also demonstrated that the system provides rough information about damage location. Progression of damage, if any, can also be detected.
Cross-categorization of legal concepts across boundaries of legal systems: in consideration of inferential links

This work contrasts Giovanni Sartor’s view of inferential semantics of legal concepts (Sartor in Artif Intell Law 17:217–251, 2009) with a probabilistic model of theory formation (Kemp et al. in Cognition 114:165–196, 2010). The work further explores possibilities of implementing Kemp’s probabilistic model of theory formation in the context of mapping legal concepts between two individual legal systems. For implementing the legal concept mapping, we propose a cross-categorization approach that combines three mathematical models: the Bayesian Model of Generalization (BMG; Tenenbaum and Griffiths in Behav Brain Sci 4:629–640, 2001), the probabilistic model of theory formation, i.e., the Infinite Relational Model (IRM) first introduced by Kemp et al. (The twenty-first national conference on artificial intelligence, 2006, Cognition 114:165–196, 2010) and its extended model, i.e., the normal-IRM (n-IRM) proposed by Herlau et al. (IEEE International Workshop on Machine Learning for Signal Processing, 2012). We apply our cross-categorization approach to datasets where legal concepts related to educational systems are respectively defined by the Japanese- and the Danish authorities according to the International Standard Classification of Education. The main contribution of this work is the proposal of a conceptual framework of the cross-categorization approach that, inspired by Sartor (Artif Intell Law 17:217–251, 2009), attempts to explain reasoner’s inferential mechanisms.
A Centrifugal Microfluidic Platform for Biomarker Detection in Blood using BluRay Technology

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Magnetic Systems, Department of Applied Mathematics and Computer Science , Cognitive Systems, Copenhagen University Hospital
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Publication: Research - peer-review › Journal article – Annual report year: 2014
Action and Language Mechanisms in the Brain: Data, Models and Neuroinformatics

We assess the challenges of studying action and language mechanisms in the brain, both singly and in relation to each other to provide a novel perspective on neuroinformatics, integrating the development of databases for encoding - separately or together - neurocomputational models and empirical data that serve systems and cognitive neuroscience.

General information

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Southern California, California Institute of Technology, University of Marburg, Purdue University, Carnegie Mellon University, Ozyegin University
Authors: Arbib, M. A. (Ekstern), Bonaiuto, J. J. (Ekstern), Bornkessel-Schlesewsky, I. (Ekstern), Kemmerer, D. (Ekstern), MacWhinney, B. (Ekstern), Nielsen, F. Å. (Intern), Oztop, E. (Ekstern)
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Scopus rating (2009): SJR 0.953 SNIP 0.975
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Adapting the Theory of Visual Attention (TVA) to model auditory attention
Mathematical and computational models have provided useful insights into normal and impaired visual attention, but less progress has been made in modelling auditory attention. We are developing a Theory of Auditory Attention (TAA), based on an influential visual model, the Theory of Visual Attention (TVA). We report that TVA provides a good fit to auditory data when the stimuli are closely matched to those used in visual studies. In the basic visual TVA task, participants view a brief display of letters and are asked to report either all of the letters (whole report) or a subset of letters (e.g., the red letters; partial report). For the auditory task, we used dichotic, concurrently-presented synthesised vowels. These auditory stimuli are closely-matched to the visual stimuli, in that they are simultaneous, separated in space, and unchanging over time. We found that TVA could successfully model the auditory data, producing good estimates of the rate at which information is encoded (C), the minimum exposure duration required for processing to begin (t0), and the relative attentional weight to targets versus distractors (α). Future work will address the issue of target-distractor confusion, and extend the model to accommodate stimuli that vary in their spectro-temporal profile.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Warwick
Authors: Roberts, K. L. (Ekstern), Andersen, T. (Intern), Kyllingsbæk, S. (Intern), Lamberts, K. (Ekstern)
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Source: dtu
Source-ID: u::10038
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Analyzing Social Interactions: Promises and Challenges of Cross Recurrence Quantification Analysis
The scientific investigation of social interactions presents substantial challenges: interacting agents engage each other at many different levels and timescales (motor and physiological coordination, joint attention, linguistic exchanges, etc.), often making their behaviors interdependent in non-linear ways. In this paper we review the current use of Cross Recurrence Quantification Analysis (CRQA) in the analysis of social interactions, and assess its potential and challenges. We argue that the method can sensitively grasp the dynamics of human interactions, and that it has started producing valuable knowledge about them. However, much work is still necessary: more systematic analyses and interpretation of the recurrence indexes and more consistent reporting of the results, more emphasis on theory-driven studies, exploring interactions involving more than 2 agents and multiple aspects of coordination, and assessing and quantifying complementary coordinative mechanisms. These challenges are discussed and operationalized in recommendations to further develop the field.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Fusaroli, R. (Ekstern), Konvalinka, I. (Intern), Wallot, S. (Ekstern)
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Are deep neural networks really learning relevant features?
In recent years deep neural networks (DNNs) have become a popular choice for audio content analysis. This may be attributed to various factors including advancements in training algorithms, computational power, and the potential for DNNs to implicitly learn a set of feature detectors. We have recently re-examined two works that consider DNNs for the task of music genre recognition (MGR). These papers conclude that frame-level features learned by DNNs offer an improvement over traditional, hand-crafted features such as Mel-frequency cepstrum coefficients (MFCCs). However, these conclusions were drawn based on training/testing using the GTZAN dataset, which is now known to contain several flaws including replicated observations and artists. We illustrate how considering these flaws dramatically changes the results, which leads one to question the degree to which the learned frame-level features are actually useful for MGR. We make available a reproducible software package allowing other researchers to completely duplicate our figures and results.

A regularized matrix factorization approach to induce structured sparse-low-rank solutions in the EEG inverse problem
We consider the estimation of the Brain Electrical Sources (BES) matrix from noisy electroencephalographic (EEG) measurements, commonly named as the EEG inverse problem. We propose a new method to induce neurophysiological meaningful solutions, which takes into account the smoothness, structured sparsity, and low rank of the BES matrix. The method is based on the factorization of the BES matrix as a product of a sparse coding matrix and a dense latent source matrix. The structured sparse-low-rank structure is enforced by minimizing a regularized functional that includes the $\ell_1$-norm of the coding matrix and the squared Frobenius norm of the latent source matrix. We develop an alternating optimization algorithm to solve the resulting nonsmooth-nonconvex minimization problem. We analyze the convergence of the optimization procedure, and we compare, under different synthetic scenarios, the performance of our method with respect to the Group Lasso and Trace Norm regularizers when they are applied directly to the target matrix.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Aalborg University
Authors: Kereliuk, C. M. (Intern), Larsen, J. (Intern), Sturm, B. L. (Forskerdatabase)
Publication date: 2014
Main Research Area: Technical/natural sciences
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General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Universidad Carlos III de Madrid, University College London
Authors: Montoya-Martinez, J. (Ekstern), Artes-Rodriguez, A. (Ekstern), Pontil, M. (Ekstern), Hansen, L. K. (Intern)
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We propose a probabilistic generative multi-view model to test the representational universality of human information processing. The model is tested in simulated data and in a well-established benchmark EEG dataset.

**Bayesian Correlated Component Analysis for inference of joint EEG activation**

Electronic versions:
A_regularized_matrix_factorization.pdf

**Bibliographical note**
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**Publication:** Research - peer-review › Journal article – Annual report year: 2014

**State:** Published
**Organisations:** Department of Applied Mathematics and Computer Science , Cognitive Systems, City University of New York

**DOIs:**

**Original language:** English
Bayesian Inference for Structured Spike and Slab Priors

Sparse signal recovery addresses the problem of solving underdetermined linear inverse problems subject to a sparsity constraint. We propose a novel prior formulation, the structured spike and slab prior, which allows to incorporate a priori knowledge of the sparsity pattern by imposing a spatial Gaussian process on the spike and slab probabilities. Thus, prior information on the structure of the sparsity pattern can be encoded using generic covariance functions. Furthermore, we provide a Bayesian inference scheme for the proposed model based on the expectation propagation framework. Using numerical experiments on synthetic data, we demonstrate the benefits of the model.

Bone Signaling in Middle Ear Development: A Genome-Wide Differential Expression Analysis

Common middle ear diseases may affect bone behavior in the middle ear air cell system. To understand this pathologic pneumatization, the normal development of bone in the middle ear should be investigated. The objective of this study was to analyze gene expression of bone-related signaling factors and gene sets in the developing middle ear. Microarray technology was used to identify bone-related genes and gene sets, which were differentially expressed between the lining tissue of adult (quiescent) bulla and young (resorbing/forming) bulla. Data were analyzed using tools of bioinformatics and expression levels of selected genes were validated using quantitative polymerase chain reaction. The candidate gene products were compared with previously published data on middle ear bone metabolism. No differentially expressed genes were found on the outer surface of bulla. On the inner lining a total of 260 genes were identified of which 22 genes were involved in bone metabolism. Gene set analysis revealed five enriched bone-related gene sets. The identified differentially expressed bone-related mRNAs and gene sets are of potential significance in the normally developing bulla. These factors and gene sets may also play important roles during pathologic pneumatization of the middle ear air cell system in common middle ear diseases. In addition, this study suggests that the control of growth rate and wall thickness from resorptive as well as formative signals all originate from the inner lining cells of the bulla wall. Anat Rec, 297:2349–2355, 2014. © 2014 Wiley Periodicals, Inc.
Brain Network Modelling

Three main topics are presented in this thesis. The first and largest topic concerns network modelling of functional Magnetic Resonance Imaging (fMRI) and Diffusion Weighted Imaging (DWI). In particular nonparametric Bayesian methods are used to model brain networks derived from resting state fMRI data. The models used are the Infinite Relational Model (IRM), Bayesian Community Detection (BCD), and Infinite Diagonal Model (IDM). The models have different constraints on how they cluster nodes. IRM is flexible in the sense that it allows for complex interactions between clusters of nodes. BCD conforms to the definition of community structure in the sense that it forces clusters of nodes to have larger density of internal connections than external connections. IDM models only the linking within a cluster and treats linking between clusters as background noise. The models are evaluated for their ability to reproduce node clustering and predict unseen data. Comparing the models on whole brain networks, BCD and IRM showed better
reproducibility and predictability than IDM, suggesting that resting state networks exhibit community structure. This also points to the importance of using models, which allow for complex interactions between all pairs of clusters. In addition, it is demonstrated how the IRM can be used for segmenting brain structures into functionally coherent clusters.

A new nonparametric Bayesian network model is presented. The model builds upon the IRM and can be used to infer shared clustering structure across different types of networks. The model is used to jointly model fMRI and DWI networks. However, results show only a limited amount of sharing across fMRI and DWI networks. Using the model within the same modality can reveal the clustering consistency across scans. A high consistency was found between DWI networks and an intermediate level of consistency was found between fMRI networks. The model is of interest for other applications, for instance in finding dissimilarity between network structure in case-control studies.

The second topic of the thesis concerns local functional connectivity. In particular the local functional connectivity is studied in patients with multiple sclerosis (MS). The functional connectivity in a small neighborhood was estimated using Kendall’s Coefficient of Concordance (KCC). By generating voxelwise KCC maps, MS patients were compared with healthy controls. MS patients had reduced KCC in cerebellum and KCC correlated negatively with disease progression. Lesion load of the left cerebellar peduncles correlated negatively with KCC suggesting that the reduced local connectivity in MS is caused by disrupted inputs to the cerebellum.

The final topic of this thesis concerns model selection for Gaussian Kernel Principal Component Analysis (KPCA) denoising. KPCA can be used for non-linear denoising by mapping data to feature space using a non-linear map. By projecting data onto a subspace in feature space and mapping this projection back to input space noise in data is (hopefully) removed. However, two important parameters must be set, namely the scale of the Gaussian kernel and the subspace dimensionality. A principled method for selecting these two parameters is presented. The method is based on maximizing the signal energy in feature space. When testing on synthetic and real data, the method outperformed a number of other heuristics in terms of signal to noise ratio of the denoised data.
Charaterization of the time-evolving bending profile of micro-cantilevers

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Community structure in resting state complex networks

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital, University of Copenhagen
Authors: Andersen, K. W. (Intern), Madsen, K. H. (Ekstern), Siebner, H. R. (Ekstern), Schmidt, M. N. (Intern), Mørup, M. (Intern), Hansen, L. K. (Intern)
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Main Research Area: Technical/natural sciences

Compact Web browsing profiles for click-through rate prediction
In real time advertising we are interested in finding features that improve click-through rate prediction. One source of available information is the bipartite graph of websites previously engaged by identifiable users. In this work, we investigate three different decompositions of such a graph with varying degrees of sparsity in the representations. The decompositions that we consider are SVD, NMF, and IRM. To quantify the utility, we measure the performances of these representations when used as features in a sparse logistic regression model for click-through rate prediction. We recommend the IRM bipartite clustering features as they provide the most compact representation of browsing patterns and yield the best performance.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Adform Aps
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Data-driven Vessel Performance Monitoring

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State: Published
Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering, Department of Applied Mathematics and Computer Science, Cognitive Systems, FORCE Technology
Authors: Pedersen, B. P. (Intern), Andersen, P. (Intern), Larsen, J. (Intern), Sinding, P. (Ekstern)
Number of pages: 272
Denoising by semi-supervised kernel PCA preimaging

Kernel Principal Component Analysis (PCA) has proven a powerful tool for nonlinear feature extraction, and is often applied as a pre-processing step for classification algorithms. In denoising applications Kernel PCA provides the basis for dimensionality reduction, prior to the so-called pre-image problem where denoised feature space points are mapped back into input space. This problem is inherently ill-posed due to the non-bijective feature space mapping. We present a semi-supervised denoising scheme based on kernel PCA and the pre-image problem, where class labels on a subset of the data points are used to improve the denoising. Moreover, by warping the Reproducing Kernel Hilbert Space (RKHS) we also account for the intrinsic manifold structure yielding a Kernel PCA basis that also benefit from unlabeled data points.

Our two main contributions are: (1) a generalization of Kernel PCA by incorporating a loss term, leading to an iterative algorithm for finding orthonormal components biased by the class labels, and (2) a fixed-point iteration for solving the pre-image problem based on a manifold warped RKHS. We prove viability of the proposed methods on both synthetic data and images from The Amsterdam Library of Object Images (Geusebroek et al., 2005) [7].
Differentiating emotional responses to images and words
The emergence of low cost electroencephalography (EEG) wireless neuroheadsets may potentially turn smartphones into pocketable labs [1], and enable design of personalized interfaces that adapt the selection of media to our emotional responses when viewing images and reading text. However such EEG responses are characterized by only small voltage changes that have typically been found in group studies involving multiple trials and large numbers of participants. Hypothesizing that spatial filtering might enhance retrieval, we apply independent component analysis (ICA) to cluster scalp maps and time series responses in a single subject based on only a few trials. Comparing our results against previous findings we identify multiple early and late ICA components that are similarly modulated by neutral, pleasant and unpleasant content in both images and words. Suggesting that we might be able to model emotional responses elicited from individual users browsing media content, which could in long term be integrated into cognitive interfaces that adapt to our preferences.
Disasters in personal informatics: The unpublished stories of failure and lessons learned

Though never a desirable outcome, failure is an inevitable part of research. Too often, however, the tried but failed paths are lost in the translation of work to publication. With the pragmatics of publishing (e.g., page limits) and the academic emphasis on positive outcomes, failed processes, methodologies, study designs, and technologies are frequently not disclosed.

This is a missed opportunity, particularly for nascent areas like Personal Informatics (PI) as well as other research areas, more generally, that share high costs in time, development, and recruitment for building and deploying testable systems. Thus, we propose a UbiComp2014 workshop focused on failures in PI research. Through short participant authored papers, breakout sessions, madness talks, and all-group discussions, our overarching workshop goals are to share “disaster” stories, reflect on lessons learned, and articulate promising paths forward.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Maryland, University of Washington, Georgia Institute of Technology
Authors: Larsen, J. E. (Intern), E. Froehlich, J. (Ekstern), Kay, M. (Ekstern), Thomaz, E. (Ekstern)
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Discovering hierarchical structure in normal relational data
Hierarchical clustering is a widely used tool for structuring and visualizing complex data using similarity. Traditionally, hierarchical clustering is based on local heuristics that do not explicitly provide assessment of the statistical saliency of the extracted hierarchy. We propose a non-parametric generative model for hierarchical clustering of similarity based on multifurcating Gibbs fragmentation trees. This allows us to infer and display the posterior distribution of hierarchical structures that comply with the data. We demonstrate the utility of our method on synthetic data and data of functional brain connectivity.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Schmidt, M. N. (Intern), Herlau, T. (Intern), Mørup, M. (Intern)
Number of pages: 6
Publication date: 2014
Down-Regulation of miR-129-5p and the let-7 Family in Neuroendocrine Tumors and Metastases Leads to Up-Regulation of Their Targets Egr1, G3bp1, Hmga2 and Bach1

Expression of miRNAs in Neuroendocrine Neoplasms (NEN) is poorly characterized. We therefore wanted to examine the miRNA expression in Neuroendocrine Tumors (NETs), and identify their targets and importance in NET carcinogenesis. miRNA expression in six NEN primary tumors, six NEN metastases and four normal intestinal tissues was characterized using miRNA arrays, and validated by in-situ hybridization and qPCR. Among the down-regulated miRNAs miR-129-5p and the let-7/let-7 family, were selected for further characterization. Transfection of miR-129-5p inhibited growth of a pulmonary and an intestinal carcinoid cell line. Analysis of mRNA expression changes identified EGR1 and G3BP1 as miR-129-5p targets. They were validated by luciferase assay and western blotting, and found robustly expressed in NETs by immunohistochemistry. Knockdown of EGR1 and G3BP1 mimicked the growth inhibition induced by miR-129-5p. let-7 overexpression inhibited growth of carcinoid cell lines, and let-7 inhibition increased protein content of the transcription factor BACH1 and its targets MMP1 and HMGA2, all known to promote bone metastases. Immunohistochemistry analysis revealed that let-7 targets are highly expressed in NETs and metastases. We found down-regulation of miR-129-5p and the let-7 family, and identified new neuroendocrine specific targets for these miRNAs, which contributes to the growth and metastatic potential of these tumors.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Rigshospitalet, University of Copenhagen, Memorial Sloan-Kettering Cancer Center, Næstved Hospital
Authors: Dossing, K. B. V. (Ekstern), Binderup, T. (Ekstern), Kaczkowski, B. (Ekstern), Jacobsen, A. (Intern), Rossing, M. (Ekstern), Winther, O. (Intern), Federspiel, B. (Ekstern), Knigge, U. (Ekstern), Kjær, A. (Intern), Friis-Hansen, L. (Ekstern)
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GENETICS, MIDGUT CARCINOID-TUMORS, TRANSCRIPTION FACTOR, MICRORNA EXPRESSION, SIGNALING PATHWAY, BINDING PROTEINS, REAL-TIME, CANCER, GROWTH, CELLS, DOMAIN
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EEG Source Reconstruction using Sparse Basis Function Representations

State of the art performance of 3D EEG imaging is based on reconstruction using spatial basis function representations. In this work we augment the Variational Garrote (VG) approach for sparse approximation to incorporate spatial basis functions. As VG handles the bias variance trade-off with cross-validation this approach is more automated than competing approaches such as Multiple Sparse Priors (Friston et al., 2008) or Champagne (Wipf et al., 2010) that require manual selection of noise level and auxiliary signal free data, respectively. Finally, we propose an unbiased estimator of the reproducibility of the reconstructed activation time course based on a split-half resampling protocol.

Efficient inference of overlapping communities in complex networks

We discuss two views on extending existing methods for complex network modeling which we dub the communities first and the networks first view, respectively. Inspired by the networks first view that we attribute to White, Boorman, and Breiger (1976)[1], we formulate the multiple-networks stochastic blockmodel (MNSBM), which seeks to separate the observed network into subnetworks of different types and where the problem of inferring structure in each subnetwork becomes easier. We show how this model is specified in a generative Bayesian framework where parameters can be inferred efficiently using Gibbs sampling. The result is an effective multiple-membership model without the drawbacks of introducing complex definitions of “groups” and how they interact. We demonstrate results on the recovery of planted structure in synthetic networks and show very encouraging results on link prediction performances using multiple-networks models on a number of real-world network data sets.

Electrophysiological assessment of audiovisual integration in speech perception

Speech perception integrates signal from ear and eye. This is witnessed by a wide range of audiovisual integration effects, such as ventriloquism and the McGurk illusion. Some behavioral evidence suggest that audiovisual integration of specific
MMN has the property of being evoked when an acoustic stimulus deviates from a learned pattern of stimuli. In three experimental studies, this effect is utilized to track when a coinciding visual signal alters auditory speech perception.

Visual speech emanates from the face of the talker. Perception of faces and of speech shares the trait, that they are learned from infancy and seemingly specialized behaviorally and neurally. Due to this, speech and face encoding functions quasi-automatically and with high efficiency. However, perhaps owing to our long experience with human faces, which all are variations on a relatively constrained space of features, face perception is sensitive to manipulations of the structure of the face, the relation between its segments, and the properties of the segments. Does this sensitivity alter the influence of visual speech on the auditory speech percept? In two experiments, which both combine behavioral and neurophysiological measures, an uncovering of the relation between perception of faces and of audiovisual integration is attempted. Behavioral findings suggest a strong effect of face perception, whereas the MMN results are less clear.

Another interesting property of speech perception is that it is relatively tolerant towards temporal shifts between acoustic and visual speech signals. Here, behavioral studies report that perception of speech exhibits far greater temporal tolerance than towards non-speech stimuli. Current findings on neural correlates of this tolerance, however, are few and limited. Here, a novel experimental MMN paradigm is used in effort to shed light on integration asynchronous audiovisual speech. Based on individual behavioral estimates of temporal windows of tolerance, we ask if the MMN signal can be evoked at different points within and outside this window. Behavioral findings match earlier behavioral studies, whereas the MMN findings are ambiguous.

In conclusion, the work presented here sheds light onto two important aspects of speech perception. It also presents important methodological conclusions on the use of MMN as a neural marker of audiovisual integration.
Fast sampling from a Hidden Markov Model posterior for large data

Hidden Markov Models are of interest in a broad set of applications including modern data driven systems involving very large data sets. However, approximate inference methods based on Bayesian averaging are precluded in such applications as each sampling step requires a full sweep over the data. We show that Approximate Bayesian Computation offers an interesting alternative for approximate sampling from the posterior distribution. In particular we use recent advances in moment based methods for HMM estimation to generate summary statistics for Approximate Bayesian Computation for large data sets offering fast access to approximate posterior samples. In a specific example we see that the new scheme is a hundred times faster than conventional Markov Chain Monte Carlo sampling using the Forward-backward method.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark
Authors: Bonnevie, R. (Ekstern), Hansen, L. K. (Intern)
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Main Research Area: Technical/natural sciences
Bioengineering, Communication, Networking and Broadcast Technologies, Computing and Processing, Engineering Profession, Signal Processing and Analysis, Approximate Bayesian Computation, Approximation methods, Bayes methods, Computational modeling, Hidden Markov Models, Markov Chain Monte Carlo, Markov processes, Moment based learning, Monte Carlo methods, Proposals
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2014
Four Data Visualization Heuristics to Facilitate Reflection in Personal Informatics

In this paper we discuss how to facilitate the process of reflection in Personal Informatics and Quantified Self systems through interactive data visualizations. Four heuristics for the design and evaluation of such systems have been identified through analysis of self-tracking devices and apps. Dashboard interface paradigms in specific self-tracking devices (Fitbit and Basis) are discussed as representative examples of state of the art in feedback and reflection support. By relating to existing work in other domains, such as event related representation of time series multivariate data in financial analytics, it is discussed how the heuristics could guide designs that would further facilitate reflection in self-tracking personal informatics systems.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Cuttone, A. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern)
Successful social interactions rely upon the abilities of two or more people to mutually exchange information in real-time, while simultaneously adapting to one another. The neural basis of social cognition has mostly been investigated in isolated individuals, and more recently using two-person paradigms to quantify the neuronal dynamics underlying social interaction. While several studies have shown the relevance of understanding complementary and mutually adaptive processes, the neural mechanisms underlying such coordinative behavioral patterns during joint action remain largely unknown. Here, we employed a synchronized finger-tapping task while measuring dual-EEG from pairs of human participants who either mutually adjusted to each other in an interactive task or followed a computer metronome. Neurophysiologically, the interactive condition was characterized by a stronger suppression of alpha and low-beta oscillations over motor and frontal areas in contrast to the non-interactive computer condition. A multivariate analysis of two-brain activity to classify interactive versus non-interactive trials revealed asymmetric patterns of the frontal alpha-suppression in each pair, during both task anticipation and execution, such that only one member showed the frontal component. Analysis of the behavioral data showed that this distinction coincided with the leader–follower relationship in 8/9 pairs, with the leaders characterized by the stronger frontal alpha-suppression. This suggests that leaders invest more resources in prospective planning and control. Hence our results show that the spontaneous emergence of leader–follower relationships in dyadic interactions can be predicted from EEG recordings of brain activity prior to and during interaction. Furthermore, this emphasizes the importance of investigating complementarity in joint action.
Grassmann Averages for Scalable Robust PCA
As the collection of large datasets becomes increasingly automated, the occurrence of outliers will increase—“big data” implies “big outliers”. While principal component analysis (PCA) is often used to reduce the size of data, and scalable solutions exist, it is well-known that outliers can arbitrarily corrupt the results. Unfortunately, state-of-the-art approaches for robust PCA do not scale beyond small-to-medium sized datasets. To address this, we introduce the Grassmann Average (GA), which expresses dimensionality reduction as an average of the subspaces spanned by the data. Because averages can be efficiently computed, we immediately gain scalability. GA is inherently more robust than PCA, but we show that they coincide for Gaussian data. We exploit that averages can be made robust to formulate the Robust Grassmann Average (RGA) as a form of robust PCA. Robustness can be with respect to vectors (subspaces) or elements of vectors; we focus on the latter and use a trimmed average. The resulting Trimmed Grassmann Average (TGA) is particularly appropriate for computer vision because it is robust to pixel outliers. The algorithm has low computational complexity and minimal memory requirements, making it scalable to “big noisy data.” We demonstrate TGA for background modeling, video restoration, and shadow removal. We show scalability by performing robust PCA on the entire Star Wars IV movie.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Max Planck Institute, University of Copenhagen
Authors: Hauberg, S. (Intern), Feragen, A. (Ekstern), Black, M. J. (Ekstern)
Pages: 3810-3817
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Series: IEEE Conference on Computer Vision and Pattern Recognition Proceedings
ISSN: 1063-6919
BFI conference series: IEEE Conference on Computer Vision and Pattern Recognition Workshops (5000075)
Main Research Area: Technical/natural sciences
Conference: 2014 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Columbus, OH, United States, 20/06/2014 - 20/06/2014
Electronic versions:
Hauberg_Grassmann_Averages_for_2014_CVPR_paper.pdf
DOIs: 10.1109/CVPR.2014.481

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Source: PublicationPreSubmission
Source-ID: 96688646
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Guest Editorial: Machine Learning for Signal Processing

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Doshisha University, Nippon Telegraph and Telephone Corporation, University of Maryland, Chinese Academy of Sciences
Authors: Katagiri, S. (Ekstern), Nakamura, A. (Ekstern), Adali, T. (Ekstern), Tao, J. (Ekstern), Larsen, J. (Intern), Tan, T. (Ekstern)
Pages: 281-283
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Signal Processing Systems
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BFI (2018): BFI-level 1
Imaging based agglutination measurement of magnetic micro-particles on a Lab-on-a-Disc platform

General information
State: Published
Organisations: Department of Physics, Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems, Magnetic Systems, Malmö University
Authors: Wantiya, P. (Ekstern), Burger, R. (Intern), Alstrøm, T. S. (Intern), Donolato, M. (Intern), Miniotis, M. F. (Ekstern), Hansen, M. F. (Intern), Wingren, A. G. (Ekstern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2014
Event: Poster session presented at 18th International Conference on Miniaturized Systems for Chemistry and Life Sciences, San Antonio, United States.
Improving spectral resolution of SERS using moving AG nanopillar substrate

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Brøgger, A. L. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Alstrøm, T. S. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014
Event: Poster session presented at 24th International Conference on Raman Spectroscopy, Jena, Germany.
Main Research Area: Technical/natural sciences
Electronic versions: Poster_ICORS.pdf
Source: PublicationPreSubmission
Source-ID: 102456688
Publication: Research - peer-review › Poster – Annual report year: 2014

Improving the robustness of Surface Enhanced Raman Spectroscopy based sensors by Bayesian Non-negative Matrix Factorization

Due to applications in areas such as diagnostics and environmental safety, detection of molecules at very low concentrations has attracted recent attention. A powerful tool for this is Surface Enhanced Raman Spectroscopy (SERS) where substrates form localized areas of electromagnetic “hot spots” where the signal-to-noise (SNR) ratio is greatly amplified. However, at low concentrations hot spots with target molecules bound are rare. Furthermore, traditional detection relies on having uncontaminated sensor readings which is unrealistic in a real world detection setting. In this paper, we propose a Bayesian Non-negative Matrix Factorization (NMF) approach to identify locations of target molecules. The proposed method is able to successfully analyze the spectra and extract the target spectrum. A visualization of the loadings of the basis vector is created and the results show a clear SNR enhancement. Compared to traditional data processing, the NMF approach enables a more reproducible and sensitive sensor.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Micro- and Nanotechnology, Surface Engineering, Nanoprobes
Authors: Alstrøm, T. S. (Intern), Frøhling, K. B. (Intern), Larsen, J. (Intern), Schmidt, M. N. (Intern), Bache, M. (Intern), Schmidt, M. S. (Intern), Jakobsen, M. H. (Intern), Boisen, A. (Intern)
Number of pages: 6
Publication date: 2014

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Title of host publication: Proceedings of the 2014 IEEE International Workshop on Machine Learning for Signal Processing (MLSP)
Publisher: IEEE
Editors: Mboup, M., Adali , T., Moreau, É., Larsen, J.
ISBN (Print): 978-1-4799-3694-6
Main Research Area: Technical/natural sciences
DOIs: 10.1109/MLSP.2014.6958925
Source: FindIt
Source-ID: 272797661
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014
Inferring Human Mobility from Sparse Low Accuracy Mobile Sensing Data

Understanding both collective and personal human mobility is a central topic in Computational Social Science. Smartphone sensing data is emerging as a promising source for studying human mobility. However, most literature focuses on high-precision GPS positioning and high-frequency sampling, which is not always feasible in a longitudinal study or for everyday applications because location sensing has a high battery cost. In this paper we study the feasibility of inferring human mobility from sparse, low accuracy mobile sensing data. We validate our results using participants’ location diaries, and analyze the inferred geographical networks, the time spent at different places, and the number of unique places over time. Our results suggest that low resolution data allows accurate inference of human mobility patterns.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Cuttone, A. (Intern), Jørgensen, S. L. (Intern), Larsen, J. E. (Intern)
Pages: 995-1004
Publication date: 2014

Infinite-degree-corrected stochastic block model

In stochastic block models, which are among the most prominent statistical models for cluster analysis of complex networks, clusters are defined as groups of nodes with statistically similar link probabilities within and between groups. A recent extension by Karrer and Newman [Karrer and Newman, Phys. Rev. E 83, 016107 (2011)] incorporates a node degree correction to model degree heterogeneity within each group. Although this demonstrably leads to better performance on several networks, it is not obvious whether modeling node degree is always appropriate or necessary. We formulate the degree corrected stochastic block model as a nonparametric Bayesian model, incorporating a parameter to control the amount of degree correction that can then be inferred from data. Additionally, our formulation yields principled ways of inferring the number of groups as well as predicting missing links in the network that can be used to quantify the model's predictive performance. On synthetic data we demonstrate that including the degree correction yields better performance on both recovering the true group structure and predicting missing links when degree heterogeneity is present, whereas performance is on par for data with no degree heterogeneity within clusters. On seven real networks (with no ground truth group structure available) we show that predictive performance is about equal whether or not degree correction is included; however, for some networks significantly fewer clusters are discovered when correcting for degree, indicating that the data can be more compactly explained by clusters of heterogenous degree nodes.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Herlau, T. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
Number of pages: 7
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Journal: Physical Review E
Volume: 90
Issue number: 3
Article number: 032819
ISSN (Print): 2470-0045
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
In the twinkling of an eye: synchronization of EEG and eye tracking based on blink signatures

ACHIEVING ROBUST ADAPTIVE SYNCHRONIZATION OF MULTIMODAL BIOMETRIC INPUTS: The recent arrival of wireless EEG headsets that enable mobile real-time 3D brain imaging on smartphones, and low cost eye trackers that provide gaze control of tablets, will radically change how biometric sensors might be integrated into next generation user interfaces. In experimental lab settings EEG neuroimaging and eye tracking data are traditionally combined using external triggers to synchronize the signals. However, with biometric sensors increasingly being applied in everyday usage scenarios, there will be a need for solutions providing a continuous alignment of signals. In the present paper we propose using spontaneous eye blinks, as a means to achieve near real-time synchronization of EEG and eye tracking. Analyzing
key parameters that define eye blink signatures across the two domains, we outline a probability function based algorithm to correlate the signals. Comparing the accuracy of the method against a state of the art EYE-EEG plug-in for offline analysis of EEG and eye tracking data, we propose our approach could be applied for robust synchronization of biometric sensor data collected in a mobile context.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Bækgaard, P. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern)
Number of pages: 6
Publication date: 2014

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Editors: Hansen, L. K., Holdt Jensen, S., Larsen, J.
ISBN (Electronic): 9 78 - 1 - 4799 - 3696 - 0
Main Research Area: Technical/natural sciences
Workshop: 4th International Workshop on Cognitive Information Processing (CIP 2014), Copenhagen, Denmark, 26/04/2014 - 26/04/2014
EEG, Eye Tracking, Synchronization
DOI:
10.1109/CIP.2014.6844504
Source: dtu
Source-ID: u::11002
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Joint Iterative Carrier Synchronization and Signal Detection Employing Expectation Maximization
Joint iterative carrier synchronization and signal detection employing expectation maximization is performed iteratively by employing expectation maximization. The parameter estimation is soft decision driven and allows joint carrier synchronization and data detection. The algorithm is tested in a mixed line rate optical transmission scenario employing dual polarization 448 Gb/s 16-QAM signal surrounded by eight on-off keying channels in a 50 GHz grid. It is shown that joint carrier synchronization and data detection are more robust towards optical transmitter impairments and nonlinear phase noise, compared to digital phase-locked loop (PLL) followed by hard decisions. Additionally, soft decision driven joint carrier synchronization and detection offers an improvement of 0.5 dB in terms of input power compared to hard decision digital PLL based carrier synchronization and demodulation.

General information
State: Published
Organisations: Department of Photonics Engineering, Metro-Access and Short Range Systems, Department of Applied Mathematics and Computer Science, Cognitive Systems, Centro de Pesquisa e Desenvolvimento em Telecomunicações
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 1.791 SJR 1.166
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.87 SJR 1.23 SNIP 1.819
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Measuring Large-Scale Social Networks with High Resolution

This paper describes the deployment of a large-scale study designed to measure human interactions across a variety of communication channels, with high temporal resolution and spanning multiple years—the Copenhagen Networks Study. Specifically, we collect data on face-to-face interactions, telecommunication, social networks, location, and background...
information (personality, demographics, health, politics) for a densely connected population of 1,000 individuals, using state-of-the-art smartphones as social sensors. Here we provide an overview of the related work and describe the motivation and research agenda driving the study. Additionally, the paper details the data types measured, and the technical infrastructure in terms of both backend and phone software, as well as an outline of the deployment procedures. We document the participant privacy procedures and their underlying principles. The paper is concluded with early results from data analysis, illustrating the importance of multi-channel high-resolution approach to data collection.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Stopczynski, A. (Intern), Sekara, V. (Intern), Sapiezynski, P. (Intern), Cuttone, A. (Intern), Madsen, M. M. (Ekstern), Larsen, J. E. (Intern), Lehmann, S. (Intern)
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Main Research Area: Technical/natural sciences

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Article number: e95978
ISSN (Print): 1932-6203
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BFI (2017): BFI-level 1
Scopus rating (2017): SJR 1.164 SNIP 1.111
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.11 SJR 1.236 SNIP 1.101
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.427 SNIP 1.136 CiteScore 3.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.559 SNIP 1.148 CiteScore 3.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.772 SNIP 1.153 CiteScore 3.94
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.982 SNIP 1.156 CiteScore 4.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.425 SNIP 1.233 CiteScore 4.58
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.705 SNIP 1.178
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.614 SNIP 1.046
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.506 SNIP 1.006
The adoption of the UN Convention on the Rights of Persons with Disabilities (UN CRPD) in 2006 has provided a global framework for work on accessibility, including information and communication technologies and audiovisual content. One of the challenges facing the application of the UN CRPD is terminology. The interpretation of concepts such as ‘disability’ and ‘accessibility’ builds on national traditions and metrics. A second challenge is implementation diversity: different nations and regions have their own interpretation of how media can be made accessible. A third challenge is the increasing number of platforms on which audiovisual content needs to be distributed, requiring very clear multiplatform architectures to facilitate interworking and assure interoperability. As a consequence, the regular evaluations of progress being made by signatories to the UN CRPD protocol are difficult to compare. Using case studies from three emerging economies (Argentina, Brazil and China) as well as industrialized nations including Canada, Denmark, the United Kingdom and the USA), this paper examines the situation facing television accessibility. Having identified and discussed existing metrics and evaluation models for access service provision, the paper identifies options that could facilitate the evaluation of UN CRPD outcomes and suggests priorities for future research in this area.

We investigate the geometrical structure of probabilistic generative dimensionality reduction models using the tools of Riemannian geometry. We explicitly define a distribution over the natural metric given by the models. We provide the...
necessary algorithms to compute expected metric tensors where the distribution over mappings is given by a Gaussian process. We treat the corresponding latent variable model as a Riemannian manifold and we use the expectation of the metric under the Gaussian process prior to define interpolating paths and measure distance between latent points. We show how distances that respect the expected metric lead to more appropriate generation of new data.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Universitat Politècnica de Catalunya, University of Sheffield
Authors: Tosi, A. (Ekstern), Hauberg, S. (Intern), Vellido, A. (Ekstern), Lawrence, N. D. (Ekstern)
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BFI conference series: Uncertainty in Artificial Intelligence (5000307)
Main Research Area: Technical/natural sciences
Conference: 30th Conference on Uncertainty in Artificial Intelligence (UAI 2014), Quebec City, Canada, 23/07/2014 - 23/07/2014
Electronic versions:
Pages_from_uai_2014_proceedings.pdf
Links:
Source: PublicationPreSubmission
Source-ID: 96688554
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

**MicroRNA expression analysis and Multiplex ligation-dependent probe amplification in metastatic and non-metastatic uveal melanoma**

Purpose: To determine the association of microRNA expression and chromosomal changes with metastasis and survival in uveal melanoma (UM). Methods: Thirty-six patients with UM were selected based on the metastatic status, and clinicopathological data were collected. Multiplex ligation-dependent probe amplification (MLPA) was used to identify chromosomal changes. Chromosomal changes and clinicopathological data were correlated with survival and metastasis. The microRNA expression was analysed in 26 of the 36 archived UM samples. Unsupervised analysis, differential expression analysis and Cox regression analysis were performed to determine the association with metastasis and survival. Results: Metastasis and metastatic death occurred in 20 patients, two patients died of other causes and one patient of unknown causes. A significant association between increasing size category (p = 0.002, log-rank), extraocular extension (p = 0.001), chromosome 3 loss (p = 0.033) and lp loss (p = 0.030) and development of metastases was observed. Tumour, node, metastasis (TNM) staging showed a significant association with survival (p <0.0001, log-rank). Adjusting for gender and age TNM size category T4 (p = 0.016, Cox regression analysis), mixed (p = 0.029) and epithelioid (p = 0.0058) cell types, chromosome 3 loss (p = 0.014) and 8q gain (p = 0.010) were significant prognosticators for a poor survival. Hierarchical clustering divided the UM into three groups based on microRNA expression. The clusters showed no association with clinical or histopathological features, TNM staging, metastasis or survival. Differential expression analysis did not reveal microRNAs related to metastasis or survival. Conclusions: The prognostic significance of chromosome 3 loss and 8q gain identified by MLPA analysis was confirmed in archived UM samples. The value of microRNA expression as a predictor of metastasis and survival in UM could not be confirmed.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen, Copenhagen University Hospital
Authors: Larsen, A. (Ekstern), Holst, L. (Ekstern), Kaczkowski, B. (Ekstern), Andersen, M. T. (Intern), Manfe, V. (Ekstern), Siersma, V. D. (Ekstern), Kolko, M. (Ekstern), Kilgaard, J. F. (Ekstern), Winther, O. (Intern), Prause, J. U. (Ekstern), Gniadecki, R. (Ekstern), Heegaard, S. (Ekstern)
Pages: 541-549
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Main Research Area: Technical/natural sciences

**Publication information**

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Volume: 92
Issue number: 6
Modeling Temporal Structure in Music for Emotion Prediction using Pairwise Comparisons

The temporal structure of music is essential for the cognitive processes related to the emotions expressed in music. However, such temporal information is often disregarded in typical Music Information Retrieval modeling tasks of predicting higher-level cognitive or semantic aspects of music such as emotions, genre, and similarity. This paper addresses the specific hypothesis whether temporal information is essential for predicting expressed emotions in music, as a prototypical example of a cognitive aspect of music. We propose to test this hypothesis using a novel processing pipeline: 1) Extracting audio features for each track resulting in a multivariate "feature time series". 2) Using generative models to represent these time series (acquiring a complete track representation). Specifically, we explore the Gaussian Mixture model, Vector Quantization, Autoregressive model, Markov and Hidden Markov models. 3) Utilizing the generative models in a discriminative setting by selecting the Probability Product Kernel as the natural kernel for all considered track representations. We evaluate the representations using a kernel based model specifically extended to support the robust two-alternative forced choice self-report paradigm, used for eliciting expressed emotions in music. The methods are evaluated using two data sets and show increased predictive performance using temporal information, thus supporting the overall hypothesis.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Madsen, J. (Intern), Jensen, B. S. (Intern), Larsen, J. (Intern)
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Bibliographical note
Source: PublicationPreSubmission
Source-ID: 101564777
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Model Selection in Data Analysis Competitions
The use of data analysis competitions for selecting the most appropriate model for a problem is a recent innovation in the field of predictive machine learning. Two of the most well-known examples of this trend was the Netflix Competition and recently the competitions hosted on the online platform Kaggle. In this paper, we will state and try to verify a set of qualitative hypotheses about predictive modelling, both in general and in the scope of data analysis competitions. To verify our hypotheses we will look at previous competitions and their outcomes, use qualitative interviews with top performers from Kaggle and use previous personal experiences from competing in Kaggle competitions. The stated hypotheses about feature engineering, ensembling, overfitting, model complexity and evaluation metrics give indications and guidelines on how to select a proper model for performing well in a competition on Kaggle.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Wind, D. K. (Intern), Winther, O. (Intern)
Pages: 55-60
Model Transport: Towards Scalable Transfer Learning on Manifolds

We consider the intersection of two research fields: transfer learning and statistics on manifolds. In particular, we consider, for manifold-valued data, transfer learning of tangent-space models such as Gaussians distributions, PCA, regression, or classifiers. Though one would hope to simply use ordinary $\mathbb{R}^n$-transfer learning ideas, the manifold structure prevents it. We overcome this by basing our method on inner-product-preserving parallel transport, a well-known tool widely used in other problems of statistics on manifolds in computer vision. At first, this straightforward idea seems to suffer from an obvious shortcoming: Transporting large datasets is prohibitively expensive, hindering scalability. Fortunately, with our approach, we never transport data. Rather, we show how the statistical models themselves can be transported, and prove that for the tangent-space models above, the transport “commutes” with learning. Consequently, our compact framework, applicable to a large class of manifolds, is not restricted by the size of either the training or test sets. We demonstrate the approach by transferring PCA and logistic-regression models of real-world data involving 3D shapes and image descriptors.
Multivariate decoding of mutually interacting brains reveals complementary neural mechanisms in leaders and followers

Non-linear calibration models for near infrared spectroscopy

Different calibration techniques are available for spectroscopic applications that show nonlinear behavior. This comprehensive comparative study presents a comparison of different nonlinear calibration techniques: kernel PLS (KPLS), support vector machines (SVM), least-squares SVM (LS-SVM), relevance vector machines (RVM), Gaussian process regression (GPR), artificial neural network (ANN), and Bayesian ANN (BANN). In this comparison, partial least squares (PLS) regression is used as a linear benchmark, while the relationship of the methods is considered in terms of traditional calibration by ridge regression (RR). The performance of the different methods is demonstrated by their practical applications using three real-life near infrared (NIR) data sets. Different aspects of the various approaches including computational time, model interpretability, potential over-fitting using the non-linear models on linear problems, robustness to small or medium sample sets, and robustness to pre-processing, are discussed. The results suggest that GPR and BANN are powerful and promising methods for handling linear as well as nonlinear systems, even when the data sets are moderately small. The LS-SVM is also attractive due to its good predictive performance for both linear and nonlinear calibrations.
Non-negative Tensor Factorization with missing data for the modeling of gene expressions in the Human Brain

Non-negative Tensor Factorization (NTF) has become a prominent tool for analyzing high dimensional multi-way structured data. In this paper we set out to analyze gene expression across brain regions in multiple subjects based on data from the Allen Human Brain Atlas [1] with more than 40 % data missing in our problem. Our analysis is based on the non-negativity constrained Canonical Polyadic (CP) decomposition where we handle the missing data using marginalization considering three prominent alternating least squares procedures; multiplicative updates, column-wise, and row-wise updating of the component matrices. We examine three gene expression prediction scenarios based on data missing at random, whole genes missing and whole areas missing within a subject. We find that the column-wise updating approach also known as HALS performs the most efficient when fitting the model. We further observe that the non-negativity constrained CP model is able to predict gene expressions better than predicting by the subject average when data is missing at random. When whole genes and whole areas are missing it is in general better to predict by subject averages. However, we find that when whole genes are missing from all subjects the model based predictions are useful. When analyzing the structure of the components derived for one of the best predicting model orders the components identified in general constitute localized regions of the brain. Non-negative tensor factorization based on marginalization thus forms a promising framework for imputing missing values and characterizing gene expression in the human brain. However, care also has to be taken in particular when predicting the genetic expression levels at a whole region of the brain missing as our analysis indicates that this requires a substantial amount of subjects with data for this region in order for the model predictions to be reliable.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Nielsen, S. F. V. (Intern), Mørup, M. (Intern)
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Publication date: 2014

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Editors: Mboup, M., Adali, T. L., Moreau, É., Larsen, J.
ISBN (Print): 978-1-4799-3694-6
Nonparametric Bayesian Clustering of Structural Whole Brain Connectivity in Full Image Resolution

Diffusion magnetic resonance imaging enables measuring the structural connectivity of the human brain at a high spatial resolution. Local noisy connectivity estimates can be derived using tractography approaches and statistical models are necessary to quantify the brain’s salient structural organization. However, statistically modeling these massive structural connectivity datasets is a computational challenging task. We develop a high-performance inference procedure for the infinite relational model (a prominent non-parametric Bayesian model for clustering networks into structurally similar groups) that defines structural units at the resolution of statistical support. We apply the model to a network of structural brain connectivity in full image resolution with more than one hundred thousand regions (voxels in the gray-white matter boundary) and around one hundred million connections. The derived clustering identifies in the order of one thousand salient structural units and we find that the identified units provide better predictive performance than predicting using the full graph or two commonly used atlases. Extracting structural units of brain connectivity at the full image resolution can aid in understanding the underlying connectivity patterns, and the proposed method for large scale data driven generation of structural units provides a promising framework that can exploit the increasing spatial resolution of neuro-imaging technologies.

Non-parametric Bayesian graph models reveal community structure in resting state fMRI

Modeling of resting state functional magnetic resonance imaging (rs-fMRI) data using network models is of increasing interest. It is often desirable to group nodes into clusters to interpret the communication patterns between nodes. In this study we consider three different nonparametric Bayesian models for node clustering in complex networks. In particular, we test their ability to predict unseen data and their ability to reproduce clustering across datasets. The three generative models considered are the Infinite Relational Model (IRM), Bayesian Community Detection (BCD), and the Infinite Diagonal Model (IDM). The models define probabilities of generating links within and between clusters and the difference between the models lies in the restrictions they impose upon the between-cluster link probabilities. IRM is the most flexible model with no restrictions on the probabilities of links between clusters. BCD restricts the between-cluster link probabilities to be strictly lower than within-cluster link probabilities to conform to the community structure typically seen in social networks. IDM only models a single between-cluster link probability, which can be interpreted as a background noise probability. These probabilistic models are compared against three other approaches for node clustering, namely Infomap, Louvain modularity, and hierarchical clustering. Using 3 different datasets comprising healthy volunteers' rs-fMRI we found that the BCD model was in general the most predictive and reproducible model. This suggests that rs-fMRI data exhibits
community structure and furthermore points to the significance of modeling heterogeneous between-cluster link probabilities.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Danish Research Centre for Magnetic Resonance, University of Copenhagen
Authors: Andersen, K. W. (Intern), Madsen, K. H. (Intern), Siebner, H. R. (Ekstern), Schmidt, M. N. (Intern), Mørup, M. (Intern), Hansen, L. K. (Intern)
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BFI (2013): BFI-level 2
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Nonparametric statistical structuring of knowledge systems using binary feature matches

Structuring knowledge systems with binary features is often based on imposing a similarity measure and clustering objects according to this similarity. Unfortunately, such analyses can be heavily influenced by the choice of similarity measure. Furthermore, it is unclear at which level clusters have statistical support and how this approach generalizes to the structuring and alignment of knowledge systems. We propose a non-parametric Bayesian generative model for structuring binary feature data that does not depend on a specific choice of similarity measure. We jointly model all combinations of binary matches and structure the data into groups at the level in which they have statistical support. The model naturally extends to structuring and aligning an arbitrary number of systems. We analyze three datasets on educational concepts and their features and demonstrate how the proposed model can both be used to structure each system separately or to jointly align two or more systems. The proposed method forms a promising new framework for the statistical modeling and alignment of structure across an arbitrary number of systems.

On the number of spanning trees in random regular graphs

Let $d \geq 3$ be a fixed integer. We give an asymptotic formula for the expected number of spanning trees in a uniformly random $d$-regular graph with $n$ vertices. (The asymptotics are as $n \to \infty$, restricted to even $n$ if $d$ is odd.) We also obtain the asymptotic distribution of the number of spanning trees in a uniformly random cubic graph, and conjecture that the corresponding result holds for arbitrary (fixed) $d$. Numerical evidence is presented which supports our conjecture.
På dynamikken fik han skik - og Abelsprisen til Sinai gik

Probabilistic shortest path tractography in DTI using Gaussian Process ODE solvers
Tractography in diffusion tensor imaging estimates connectivity in the brain through observations of local diffusivity. These observations are noisy and of low resolution and, as a consequence, connections cannot be found with high precision. We use probabilistic numerics to estimate connectivity between regions of interest and contribute a Gaussian Process tractography algorithm which allows for both quantification and visualization of its posterior uncertainty. We use the uncertainty both in visualization of individual tracts as well as in heat maps of tract locations. Finally, we provide a quantitative evaluation of different metrics and algorithms showing that the adjoint metric [8] combined with our algorithm produces paths which agree most often with experts.
Ranking Entities in Networks via Lefschetz Duality
In the theory of communication it is essential that agents are able to exchange information. This fact is closely related to the study of connected spaces in topology. A communication network may be modelled as a topological space such that agents can communicate if and only if they belong to the same path connected component of that space. In order to study combinatorial properties of such a space, notions from algebraic topology are applied. This makes it possible to determine the shape of a network by concrete invariants, e.g. the number of connected components. Elements of a network may then be ranked according to how essential their positions are in the network by considering the effect of their respective absences. Defining a ranking of a network which takes the individual position of each entity into account has the purpose of assigning different roles to the entities, e.g. agents, in the network. In this paper it is shown that the topology of a given network induces a ranking of the entities in the network. Further, it is demonstrated how to calculate this ranking and thus how to identify weak sub-networks in any given network.

S-AMP: Approximate Message Passing for General Matrix Ensembles
We propose a novel iterative estimation algorithm for linear observation models called S-AMP. The fixed points of S-AMP are the stationary points of the exact Gibbs free energy under a set of (first- and second-) moment consistency constraints in the large system limit. S-AMP extends the approximate message-passing (AMP) algorithm to general matrix ensembles with a well-defined large system size limit. The generalization is based on the S-transform (in free probability) of the spectrum of the measurement matrix. Furthermore, we show that the optimality of S-AMP follows directly from its design rather than from solving a separate optimization problem as done for AMP.
Semi-supervised eigenvectors for large-scale locally-biased learning

In many applications, one has side information, e.g., labels that are provided in a semi-supervised manner, about a specific target region of a large data set, and one wants to perform machine learning and data analysis tasks nearby that prespecified target region. For example, one might be interested in the clustering structure of a data graph near a prespecified seed set of nodes, or one might be interested in finding partitions in an image that are near a prespecified ground truth set of pixels. Locally-biased problems of this sort are particularly challenging for popular eigenvector-based machine learning and data analysis tools. At root, the reason is that eigenvectors are inherently global quantities, thus limiting the applicability of eigenvector-based methods in situations where one is interested in very local properties of the data.

In this paper, we address this issue by providing a methodology to construct semi-supervised eigenvectors of a graph Laplacian, and we illustrate how these locally-biased eigenvectors can be used to perform locally-biased machine learning. These semi-supervised eigenvectors capture successively-orthogonalized directions of maximum variance, conditioned on being well-correlated with an input seed set of nodes that is assumed to be provided in a semi-supervised manner. We show that these semi-supervised eigenvectors can be computed quickly as the solution to a system of linear equations; and we also describe several variants of our basic method that have improved scaling properties. We provide several empirical examples demonstrating how these semi-supervised eigenvectors can be used to perform locally-biased learning; and we discuss the relationship between our results and recent machine learning algorithms that use global eigenvectors of the graph Laplacian.
Mobile brain imaging solutions, such as the Smartphone Brain Scanner, which combines low cost wireless EEG sensors with open source software for real-time neuroimaging, may transform neuroscience experimental paradigms. Normally subject to the physical constraints in labs, neuroscience experimental paradigms can be transformed into dynamic environments allowing for the capturing of brain signals in everyday contexts. Using smartphones or tablets to access text or images may enable experimental design capable of tracing emotional responses when shopping or consuming media, incorporating sensorimotor responses reflecting our actions into brain machine interfaces, and facilitating neurofeedback training over extended periods. Even though the quality of consumer neuroheadsets is still lower than laboratory equipment and susceptible to environmental noise, we show that mobile neuroimaging solutions, like the Smartphone Brain Scanner, complemented by 3D reconstruction or source separation techniques may support a range of neuroimaging applications and thus become a valuable addition to high-end neuroimaging solutions.
Supplementary Notes for Graph Theory 1: Including solutions for selected weekly exercises

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The Fire-Walker's High: Affect and Physiological Responses in an Extreme Collective Ritual

How do people feel during extreme collective rituals? Despite longstanding speculation, few studies have attempted to quantify ritual experiences. Using a novel pre/post design, we quantified physiological fluctuations (heart rates) and self-reported affective states from a collective fire-walking ritual in a Mauritian Hindu community. Specifically, we compared changes in levels of happiness, fatigue, and heart rate reactivity among high-ordeal participants (fire-walkers), low-ordeal participants (non-fire-walking participants with familial bonds to fire-walkers) and spectators (unrelated/unknown to the fire-walkers). We observed that fire-walkers experienced the highest increase in heart rate and reported greater happiness post-ritual compared to low-ordeal participants and spectators. Low-ordeal participants reported increased fatigue after the ritual compared to both fire-walkers and spectators, suggesting empathetic identification effects. Thus, witnessing the ritualistic suffering of loved ones may be more exhausting than experiencing suffering oneself. The findings demonstrate that the level of ritual involvement is important for shaping affective responses to collective rituals. Enduring a ritual ordeal is associated with greater happiness, whereas observing a loved-one endure a ritual ordeal is associated with greater fatigue post-ritual.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Victoria University of Wellington, Aarhus University, Masaryk University
Authors: Fischer, R. (Ekstern), Xygalatas, D. (Forskerdatabase), Mitkidis, P. (Forskerdatabase), Reddish, P. (Ekstern), Tok, P. (Ekstern), Konvalinka, I. (Intern), Bulbulia, J. (Ekstern)
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Scopus rating (2014): SJR 1.559 SNIP 1.148 CiteScore 3.54
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The impact of hazardous industrial facilities on housing prices: A comparison of parametric and semiparametric hedonic price models

The willingness of households to pay for prevention against industrial risks can be revealed by real estate markets. By using very rich microdata, we study housing prices in the vicinity of hazardous industries near three important French cities. We show that the impact of hazardous plants on the housing values strongly differs among these three areas, even if the areas all surround chemical and petrochemical industries. We compare the results from both standard parametric and more flexible, semiparametric models of hedonic property. We show that the parametric model might structurally lead to important biases in the estimated value of the impact of hazardous plants on housing values.

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Authors: Grislain-Letrémy, C. (Ekstern), Katossky, A. (Intern)
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BFI (2014): BFI-level 1
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The Long Tail Issue in Large Scale Deployment of Personal Informatics

We describe the challenges and the open questions arising during the design and deployment of SensibleJournal, a mobile personal informatics system with interactive visualizations of mobility and social interactions based on data acquired from embedded smartphone sensors. The SensibleJournal system was evaluated in a large scale (N=136) mobile sensing field study. We report issues in deployment, limitations in user engagement and uptake, and the challenges in measuring the effect of the system.

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Authors: Cuttone, A. (Intern), Larsen, J. E. (Intern)
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The role of simulation in designing for universal access

It is known that the adoption of user-centred design processes can lead to more universally accessible products and services. However, the most frequently cited approach to user-centred design, i.e. participatory design, can be both problematic and expensive to implement, particularly over the difficulty of finding and recruiting suitable participants. Simulation aids offer a potentially cost-effective replacement or complement to participatory design. This paper examines a number of the issues associated with the use of simulation aids when designing for Universal Access. It concludes that simulation aids can play an effective role, but need to be used with due consideration over what insights they provide.

The Smartphone Brain Scanner: A Portable Real-Time Neuroimaging System

Combining low-cost wireless EEG sensors with smartphones offers novel opportunities for mobile brain imaging in an everyday context. Here we present the technical details and validation of a framework for building multi-platform, portable EEG applications with real-time 3D source reconstruction. The system – Smartphone Brain Scanner – combines an off-the-shelf neuroheadset or EEG cap with a smartphone or tablet, and as such represents the first fully portable system for real-time 3D EEG imaging. We discuss the benefits and challenges, including technical limitations as well as details of real-time reconstruction of 3D images of brain activity. We present examples of brain activity captured in a simple experiment involving imagined finger tapping, which shows that the acquired signal in a relevant brain region is similar to that obtained with standard EEG lab equipment. Although the quality of the signal in a mobile solution using an off-the-shelf consumer neuroheadset is lower than the signal obtained using high-density standard EEG equipment, we propose mobile application development may offset the disadvantages and provide completely new opportunities for neuroimaging in natural settings.
The Strength of Friendship Ties in Proximity Sensor Data

Understanding how people interact and socialize is important in many contexts from disease control to urban planning. Datasets that capture this specific aspect of human life have increased in size and availability over the last few years. We have yet to understand, however, to what extent such electronic datasets may serve as a valid proxy for real life social interactions. For an observational dataset, gathered using mobile phones, we analyze the problem of identifying transient and non-important links, as well as how to highlight important social interactions. Applying the Bluetooth signal strength parameter to distinguish between observations, we demonstrate that weak links, compared to strong links, have a lower probability of being observed at later times, while such links—on average—also have lower link-weights and probability of sharing an online friendship. Further, the role of link-strength is investigated in relation to social network properties.

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Web of Science (2012): Indexed yes
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Scopus rating (2010): SJR 2.705 SNIP 1.178
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 2.614 SNIP 1.046
The Strength of the Strongest Ties in Collaborative Problem Solving

Complex problem solving in science, engineering, and business has become a highly collaborative endeavor. Teams of scientists or engineers collaborate on projects using their social networks to gather new ideas and feedback. Here we bridge the literature on team performance and information networks by studying teams’ problem solving abilities as a function of both their within-team networks and their members’ extended networks. We show that, while an assigned team’s performance is strongly correlated with its networks of expressive and instrumental ties, only the strongest ties in both networks have an effect on performance. Both networks of strong ties explain more of the variance than other factors, such as measured or self-evaluated technical competencies, or the personalities of the team members. In fact, the inclusion of the network of strong ties renders these factors non-significant in the statistical analysis. Our results have consequences for the organization of teams of scientists, engineers, and other knowledge workers tackling today’s most complex problems.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Massachusetts Institute of Technology
Authors: de Montjoye, Y. (Ekstern), Stopczynski, A. (Intern), Shmueli, E. (Ekstern), Pentland, A. (Ekstern), Jørgensen, S. L. (Intern)
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Tumor antigens as proteogenomic biomarkers in invasive ductal carcinomas

Background: The majority of genetic biomarkers for human cancers are defined by statistical screening of high-throughput genomics data. While a large number of genetic biomarkers have been proposed for diagnostic and prognostic applications, only a small number have been applied in the clinic. Similarly, the use of proteomics methods for the discovery of cancer biomarkers is increasing. The emerging field of proteogenomics seeks to enrich the value of genomics and proteomics approaches by studying the intersection of genomics and proteomics data. This task is challenging due to the complex nature of transcriptional and translation regulatory mechanisms and the disparities between genomic and proteomic data from the same samples. In this study, we have examined tumor antigens as potential biomarkers for breast cancer using genomics and proteomics data from previously reported laser capture microdissected ER+ tumor samples.

Results: We applied proteogenomic analyses to study the genetic aberrations of 32 tumor antigens determined in the proteomic data. We found that tumor antigens that are aberrantly expressed at the genetic level and expressed at the protein level, are likely involved in perturbing pathways directly linked to the hallmarks of cancer. The results found by proteogenomic analysis of the 32 tumor antigens studied here, capture largely the same pathway irregularities as those elucidated from large-scale screening of genomics analyses, where several thousands of genes are often found to be perturbed.

Conclusion: Tumor antigens are a group of proteins recognized by the cells of the immune system. Specifically, they are recognized in tumor cells where they are present in larger than usual amounts, or are physiochemically altered to a degree at which they no longer resemble native human proteins. This proteogenomic analysis of 32 tumor antigens suggests that tumor antigens have the potential to be highly specific biomarkers for different cancers.
Validity of covariance models for the analysis of geographical variation

1. Due to the availability of large molecular data-sets, covariance models are increasingly used to describe the structure of genetic variation as an alternative to more heavily parametrised biological models.

2. We focus here on a class of parametric covariance models that received sustained attention lately and show that the conditions under which they are valid mathematical models have been overlooked so far.

3. We provide rigorous results for the construction of valid covariance models in this family.

4. We also outline how to construct alternative covariance models for the analysis of geographical variation that are both mathematically well behaved and easily implementable.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Dresden University of Technology, Universidad de Valparaiso, Universidad Tecnica Federico Santa Maria
Authors: Guillot, G. (Intern), Schilling, R. L. (Ekstern), Porcu, E. (Ekstern), Bevilacqua, M. (Ekstern)
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Visualizing multi-channel networks

In this paper, we propose a visualization to illustrate social interactions, built from multiple distinct channels of communication. The visualization displays a summary of dense personal information in a compact graphical notation. The starting point is an abstract drawing of a spider’s web. Below, we describe the meaning of each data dimension along with the background and motivation for their inclusion. Finally, we present feedback provided by the users (31 individuals) of the visualization.

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Authors: Antemijczuk, P. (Ekstern), Magiera, M. (Ekstern), Jørgensen, S. L. (Intern), Cuttone, A. (Intern), Larsen, J. E. (Intern)
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Visualizing QS Data Using Time Spirals

Wikipedia in the eyes of its beholders: A systematic review of scholarly research on Wikipedia readers and readership

Wikipedia in the eyes of its beholders: A systematic review of scholarly research on Wikipedia readers and readership

Hundreds of scholarly studies have investigated various aspects of Wikipedia. Although a number of literature reviews have provided overviews of this vast body of research, none has specifically focused on the readers of Wikipedia and issues concerning its readership. In this systematic literature review, we review 99 studies to synthesize current knowledge regarding the readership of Wikipedia and provide an analysis of research methods employed. The scholarly research has found that Wikipedia is popular not only for lighter topics such as entertainment but also for more serious topics such as health and legal information. Scholars, librarians, and students are common users, and Wikipedia provides a unique opportunity for educating students in digital literacy. We conclude with a summary of key findings, implications for researchers, and implications for the Wikipedia community.
Your heart might give away your emotions
Estimating emotional responses to pictures based on heart rate measurements: Variations in Heart Rate serves as an important clinical health indicator, but potentially also as a window into cognitive reactions to presented stimuli, as a function of both stimuli, context and previous cognitive state. This study looks at single-trial time domain mean Heart Rate (HR) and frequency domain Heart Rate Variability (HRV) measured while subjects were passively viewing emotionally engaging images, comparing short random presentations with grouped sequences of either neutral, highly arousing pleasant or highly arousing unpleasant pictures. For the grouped sequences, we found a trend in the mean HR that could correlate with the emotional content of the images, but no such trends was seen in the random trials. We were, however, not able to demonstrate HRV variations that correlated with the presented emotional content, nor could we reproduce earlier studies, with different experimental setups that were based on average values over many subjects, that had revealed small changes in the mean HR only seconds after presentation.

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Authors: Laundav, D. K. (Ekstern), Jensen, C. B. F. (Intern), Bækgaard, P. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern)
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3D gender recognition using cognitive modeling

We use 3D scans of human faces and cognitive modeling to estimate the “gender strength”. The “gender strength” is a continuous class variable of the gender, superseding the traditional binary class labeling. To visualize some of the visual trends humans use when performing gender classification, we use linear regression. In addition, we use the gender strength to construct a smaller but refined training set, by identifying and removing ill-defined training examples. We use this refined training set to improve the performance of known classification algorithms. Results are presented using a 5-fold cross-validation scheme and also reproduced using an unseen data set.

A Hierarchical Bayesian M/EEG Imaging Method Correcting for Incomplete Spatio-Temporal Priors

In this paper we present a hierarchical Bayesian model, to tackle the highly ill-posed problem that follows with MEG and EEG source imaging. Our model promotes spatiotemporal patterns through the use of both spatial and temporal basis functions. While in contrast to most previous spatio-temporal inverse M/EEG models, the proposed model benefits of
consisting of two source terms, namely, a spatiotemporal pattern term limiting the source configuration to a spatio-temporal subspace and a source correcting term to pick up source activity not covered by the spatio-temporal prior belief. Both artificial data and real EEG data is used to demonstrate the efficacy of the model.

A Mobile Personal Informatics System with Interactive Visualizations of Mobility and Social Interactions
We describe a personal informatics system for Android smartphones that provides personal data on mobility and social interactions through interactive visualization interfaces. The mobile app has been made available to N=136 first year university students as part of a study of social network interactions in a university campus setting. The design of the interactive visualization interfaces enabling the participants to gain insights into own behaviors is described. We report initial findings based on device logging of participant interactions with the interactive visualization app on the smartphone and from a survey on usage with response from 45 (33%) of the participants indicating that the system allowed new insights into behavioral patterns.

Analysis of Conceptualization Patterns across Groups of People
This paper analyzes patterns of conceptualizations possessed by different groups of subjects. The eventual goal of this work is to dynamically learn and structure semantic representations for groups of people sharing domain knowledge. In this paper, we conduct a survey for collecting data representing semantic representations of 34 subjects with different
profiles in gender and educational background. The collected data is analyzed by an approach combining two extended versions of the Infinite Relational Model (Kemp et al. 2006) [1]: multiarray Infinite Relational Model (Mørup et al. 2010) [2] and normal Infinite Relational Model (Herlau et al. 2012) [3]. Results indicate that the employed approach not only localizes similar patterns of conceptualization within a group of subjects having a common profile, but also identifies differences in conceptualization across different subject groups.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen Business School, Hokkaido University
Authors: Glückstad, F. K. (Ekstern), Herlau, T. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern), Rzepka, R. (Ekstern), Araki, K. (Ekstern)
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Analysis of Subjective Conceptualizations Towards Collective Conceptual Modelling
This work is conducted as a preliminary study for a project where individuals' conceptualizations of domain knowledge will thoroughly be analyzed across 150 subjects from 6 countries. The project aims at investigating how humans' conceptualizations differ according to different types of mother languages, cultural backgrounds, gender, generations, etc., when domain-specific terms are expressed in a common language, i.e. English. In this work, we analyze a publicly available dataset [De Deyne, 2008] representing semantic structures of domain knowledge possessed by four subjects. The application of a non-parametric relational model, Infinite Relational Model [Kemp, 2006] co-clusters concept-feature relations, which identifies a common semantic structural grid across the four subjects considered. Through this common grid, the individual semantic structures possessed by the respective subjects are further contrasted to each other. The results show that the identified common grid visualizes subject specific patterns among the extracted concept-feature clusters. The work further discusses our future perspectives for modeling a collective ontology across subjects according to different subjects' profiles.

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Authors: Glückstad, F. K. (Ekstern), Herlau, T. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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A Neural Marker of Perceptual Consciousness in Infants
Consciousness Arrives Neurophysiological measures in human adults correspond to the transition between very brief, "unnoticeable," and slightly longer-lived visual stimuli that penetrate deeply enough to leave a conscious imprint that subjects report they can "see." Kouider et al. (p. 376) have performed parallel behavioral and neurophysiological studies in infants to identify a similar neural signal that appears to mark the development of visual consciousness.
Archetypal analysis of diverse Pseudomonas aeruginosa transcriptomes reveals adaptation in cystic fibrosis airways

BACKGROUND: Analysis of global gene expression by DNA microarrays is widely used in experimental molecular biology. However, the complexity of such high-dimensional data sets makes it difficult to fully understand the underlying biological features present in the data. The aim of this study is to introduce a method for DNA microarray analysis that provides an intuitive interpretation of data through dimension reduction and pattern recognition. We present the first “Archetypal Analysis” of global gene expression. The analysis is based on microarray data from five integrated studies of Pseudomonas aeruginosa isolated from the airways of cystic fibrosis patients. RESULTS: Our analysis clustered samples into distinct groups with comprehensible characteristics since the archetypes representing the individual groups are closely related to samples present in the data set. Significant changes in gene expression between different groups identified adaptive changes of the bacteria residing in the cystic fibrosis lung. The analysis suggests a similar gene expression pattern between isolates with a high mutation rate (hypermutators) despite accumulation of different mutations for these isolates. This suggests positive selection in the cystic fibrosis lung environment, and changes in gene expression for these isolates are therefore most likely related to adaptation of the bacteria. CONCLUSIONS: Archetypal analysis succeeded in identifying adaptive changes of P. aeruginosa. The combination of clustering and matrix factorization made it possible to reveal minor similarities among different groups of data, which other analytical methods failed to identify. We suggest that this analysis could be used to supplement current methods used to analyze DNA microarray data.
Assessing Miniaturized Sensor Performance using Supervised Learning, with Application to Drug and Explosive Detection

This Ph.D. thesis titled "Assessing Miniaturized Sensor Performance using Supervised Learning, with Application to Drug and Explosive Detection" is a part of the strategic research project “Miniaturized sensors for explosives detection in air” funded by the Danish Agency for Science and Technology’s, Program Commission on Nanoscience Biotechnology and IT (NABIIT), case number: 2106-07-0031. The project, baptized “Xsense” was led by professor Anja Boisen, DTU Nanotech.
DTU Informatics participate in the project as data analysis partner.

This thesis presents advances in the area of detection of vapor emanated by explosives and drugs, similar to an electronic nose. To evaluate sensor responses a data processing and evaluation pipeline is required. The work presented herein focuses on the feature extraction, feature representation and sensor accuracy. Thus the primary aim of this thesis is twofold; firstly, present methods suitable for assessing sensor accuracy, and secondly improve sensor performance by enhancing the preprocessing and feature extraction.

Five different miniaturized sensors are presented. Naturally, each sensor require its own special preprocessing and feature extraction techniques before the sensor responses can be applied to supervised learning algorithms. The technologies used for sensing consist of Calorimetry, Cantilevers, Chemoselective compounds, Quartz Crystal Microbalance and Surface Enhanced Raman Scattering. Each of the sensors have their own strength and weaknesses. The reasoning for using multiple sensors was the desire to investigate the feasibility for an integrated multisensor solution. A unique setup of multiple independent detectors is able to vastly enhance accuracy compared to what a single sensor can deliver. As we are detecting hazardous compounds this enables the need for sensors to deliver not only decisions but also certainty about decisions. This requirement is handled by introducing classifiers that offer posterior probabilities and not only decisions. The three probabilistic classification models utilized are Artificial Neural Networks, Logistic Regression and Gaussian Processes. Often, there is no tradition for using these methods in the communities of the prescribed sensors. Here, a method of too much complexity is often undesired so it is a balance when to utilize more sophisticated methods. For this reason, an array of methods that only discriminate between samples are used as baseline. The methods used vary from sensor to sensor, as these methods serve as baseline performance when introducing new methods. The most widely used baseline method in this thesis is the k-nearest-neighbor algorithm. This method is of particular interest in the application of sensors, as the sensors are designed to provide robust and reliable measurements. That means, the sensors are designed to have repeated measurement clusters. Sensor fusion is presented for the sensor based on chemoselective compounds.

An array of color changing compounds are handled and in unity they make up an colorimetric sensor array. In this setting it is valuable to qualify which compounds in the colorimetric sensor array are important. That knowledge enables the ability to either reduce the size of the sensor or replace less sensitive and unimportant compounds with more selective and responsive compounds. A framework based on forward selection Gaussian Process classification is demonstrated to successfully identify a set of important compounds.

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Authors: Alstrøm, T. S. (Intern), Larsen, J. (Intern)
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Autobiographical Memory in a Fire-Walking Ritual
Abstract Anthropological theories have discussed the effects of participation in high-arousal rituals in the formation of autobiographical memory; however, precise measurements for such effects are lacking. In this study, we examined episodic recall among participants in a highly arousing fire-walking ritual. To assess arousal, we used heart rate measurements. To assess the dynamics of episodic memories, we obtained reports immediately after the event and two months later. We evaluated memory accuracy from video footage. Immediately after the event, participants’ reports revealed limited recall, low confidence and high accuracy. Two months later we found more inaccurate memories and higher confidence. Whereas cognitive theories of ritual have predicted flashbulb memories for highly arousing rituals, we found that memories were strongly suppressed immediately after the event and only later evolved confidence and detail. Physiological measurements revealed a spectacular discrepancy between actual heart rates and self-reported arousal. This dissociation between subjective reports and objective measurements of arousal is consistent with a cognitive resource depletion model. We argue that expressive suppression may provide a link between individual memories and cultural understandings of high-arousal rituals.

General information
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Believing versus interacting: Behavioural and neural mechanisms underlying interpersonal coordination

When two people engage in a bidirectional interaction with each other, they use both bottom-up sensorimotor mechanisms such as monitoring and adapting to the behaviour of the other, as well as top-down cognitive processes, modulating their beliefs and allowing them to make decisions. Most research in joint action has investigated only one of these mechanisms at a time – low-level processes underlying joint coordination, or high-level cognitive mechanisms that give insight into how people think about another. In real interactions, interplay between these two mechanisms modulates how we interact with
others. In order to tease these apart in a mutual interaction, we conducted a synchronization-tapping experiment using a 2x2 factorial design, where one factor was the auditory feedback (hearing other or computer), and the other was the belief of what they were hearing (other or computer). MEG was measured from one co-actor, with the other co-actor seated outside the scanner. Our findings show frontal alpha suppression during anticipation of the task with a person vs. a computer, and frontal-sensorimotor suppression during task execution with the person vs. computer. This provides insight into neural mechanisms underlying belief of interacting with another person as well as engaging in interaction with the responsive other.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Konvalinka, I. (Intern), Bauer, M. (Ekstern), Kilner, J. (Ekstern), Roepstorff, A. (Ekstern), Frith, C. D. (Ekstern)
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**Bounded Gaussian process regression**
We extend the Gaussian process (GP) framework for bounded regression by introducing two bounded likelihood functions that model the noise on the dependent variable explicitly. This is fundamentally different from the implicit noise assumption in the previously suggested warped GP framework. We approximate the intractable posterior distributions by the Laplace approximation and expectation propagation and show the properties of the models on an artificial example. We finally consider two real-world data sets originating from perceptual rating experiments which indicate a significant gain obtained with the proposed explicit noise-model extension.

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**Comparing Structural Brain Connectivity by the Infinite Relational Model**
The growing focus in neuroimaging on analyzing brain connectivity calls for powerful and reliable statistical modeling tools. We examine the Infinite Relational Model (IRM) as a tool to identify and compare structure in brain connectivity graphs by contrasting its performance on graphs from the same subject versus graphs from different subjects. The inferred structure is most consistent between graphs from the same subject, however, the model is able to predict links in graphs from different subjects on par with results within a subject. The framework proposed can be used as a statistical modeling tool for the identification of structure and quantification of similarity in graphs of brain connectivity in general.

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Authors: Ambrosen, K. M. S. (Intern), Herlau, T. (Intern), Dyby, T. (Ekstern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
Pages: 50-53
Complementary coordination strategies in a joint Fitts' reciprocal aiming task

How do dyads coordinate their actions to achieve a common goal when one person has the more difficult task? In the present study, dyads were instructed to engage in a Fitts's reciprocal aiming task as accurately as possible, and at a given tempo sent through their headphones. They were in conditions where they either received auditory feedback of 1) SELF-generated taps, 2) taps generated by the OTHER co-actor, or 3) regular, COMPUTER-generated taps. In conditions 2) and 3), they were also instructed to synchronize with their feedback as best as possible. In each trial, each participant was assigned to either the target's role – with varying target width, and hence task difficulty – or the reference role – with the widest (easiest) target. Results show that when the task was performed interactively with the other person, they were most synchronized, and also used the target most similarly, while compromising rhythmic accuracy. In addition, as task difficulty increased for the member with the target’s role, the participant with the reference role became more adaptive to her tempo. This suggests that interacting members of a dyad optimally negotiate coordination strategies to achieve a joint goal, by taking on leader-follower roles.

Crowds, Bluetooth and Rock'n'Roll: Understanding Music Festival Participant Behavior

In this paper we present a study of sensing and analyzing an offline social network of participants at a large-scale music festival (8 days, 130,000+ participants). We place 33 fixed-location Bluetooth scanners in strategic spots around the festival area to discover Bluetooth-enabled mobile phones carried by the participants, and thus collect spatio-temporal traces of their mobility and interactions. We subsequently analyze the data on two levels. On the micro level, we run a community detection algorithm to reveal a variety of groups the festival participants form. On the macro level, we employ an Infinite Relational Model (IRM) in order to recover the structure of the social network related to participants’ music preferences. The obtained structure in the form of clusters of concerts and participants is then interpreted using meta-information about music genres, band origins, stages, and dates of performances. We show that most of the concerts clusters can be described by one or more of the meta-features, effectively revealing preferences of participants (e.g. a cluster of US bands) and discuss the significance of the findings and the potential and limitations of the used method. Finally, we discuss the possibility of employing the described method and techniques for creating user-oriented applications and extending the sensing capabilities during large-scale events by introducing user involvement.
Crowds, Bluetooth, and Rock’n’Roll: Understanding Music Festival Participant Behavior

In this paper we present a study sensing and analyzing an offline social network of participants at a large-scale music festival attended by 130,000+ participants, and featuring eight days of musical program on 6 stages. Spatio-temporal traces of participant mobility and interactions were collected from 33 Bluetooth scanners placed in strategic locations at the festival area to discover Bluetooth-enabled mobile phones carried by the participants. We employed an Infinite Relational Model (IRM) in order to analyze the collected data and to recover the structure of the network related to participants' music preferences. The obtained structure in the form of clusters of concerts and participants is then interpreted using meta-information about music genres, band origins, stages, and dates of the performances. We show that the concerts' clusters can be described by one or more of the meta-features, effectively revealing preferences of participants. Finally, we discuss the possibility of employing the described method and techniques for creating user-oriented applications and extending the sensing capabilities during large-scale events by introducing user involvement.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Larsen, J. E. (Intern), Sapiezynski, P. (Intern), Stopczynski, A. (Intern), Mørup, M. (Intern), Theodorsen, R. (Ekstern)
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Dimensionality reduction for click-through rate prediction: Dense versus sparse representation

In online advertising, display ads are increasingly being placed based on real-time auctions where the advertiser who wins gets to serve the ad. This is called real-time bidding (RTB). In RTB, auctions have very tight time constraints on the order of 100ms. Therefore mechanisms for bidding intelligently such as clickthrough rate prediction need to be sufficiently fast. In this work, we propose to use dimensionality reduction of the user-website interaction graph in order to produce simplified features of users and websites that can be used as predictors of clickthrough rate. We demonstrate that the Infinite Relational Model (IRM) as a dimensionality reduction offers comparable predictive performance to conventional dimensionality reduction schemes, while achieving the most economical usage of features and fastest computations at run-time. For applications such as real-time bidding, where fast database I/O and few computations are key to success, we thus recommend using IRM based features as predictors to exploit the recommender effects from bipartite graphs.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Fruergaard, B. Ø. (Intern), Hansen, T. J. (Intern), Hansen, L. K. (Intern)
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EEG Sequence Imaging: A Markov Prior for the Variational Garrote

We propose the following generalization of the Variational Garrote for sequential EEG imaging: A Markov prior to promote sparse, but temporally smooth source dynamics. We derive a set of modified Variational Garrote updates and analyze the role of the prior's hyperparameters. An experimental evaluation is given in simulated data and in a benchmark EEG data set.

Efficient individualization of hearing aid processed sound

Due to the large amount of options offered by the vast number of adjustable parameters in modern digital hearing aids, it is becoming increasingly daunting—even for a fine-tuning professional—to perform parameter fine tuning to satisfactorily meet the preference of the hearing aid user. In addition, the communication between the fine-tuning professional and the hearing aid user might muddle the task. In the present paper, an interactive system is proposed to ease and speed up fine tuning of hearing aids to suit the preference of the individual user. The system simultaneously makes the user conscious of his own preferences while the system itself learns the user's preference. Since the learning is based on probabilistic modeling concepts, the system handles inconsistent user feedback efficiently. Experiments with hearing impaired subjects show that the system quickly discovers individual preferred hearing-aid settings which are consistent across consecutive fine-tuning sessions for each user.
Estimating passenger numbers in trains using existing weighing capabilities

Knowing passenger numbers is important for the planning and operation of the urban rail systems. Manual and electronic counting systems (typically infrared or video) are expensive and therefore entail small sample sizes. They usually count boarding and alighting passengers, which means that errors in estimates of total numbers of passengers propagate along train runs. Counting errors in manual and electronic counting systems are typically flow-dependent, making uncertainty a function of volume. This paper presents a new counting technique that exploits the weighing systems installed in most modern trains to control braking. This technique makes passenger counting cheaper and ensures a complete sample. The paper compares numbers estimated by this technique with manual counts and counts from an infrared system in trains in urban Copenhagen. It shows that the weighing system provides more accurate passenger counts than the infrared equipment. The method has been validated on a large data set and is now in full operation in the urban Copenhagen rail system.

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Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Cognitive Systems, Department of Transport, Traffic modelling and planning, Danish Road Directorate
Authors: Nielsen, B. F. (Intern), Frølich, L. (Intern), Nielsen, O. A. (Intern), Filges, D. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.808 SNIP 1.214
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Expansion of the Variational Garrote to a Multiple Measurement Vectors Model

The recovery of sparse signals in underdetermined systems is the focus of this paper. We propose an expanded version of the Variational Garrote, originally presented by Kappen (2011), which can use multiple measurement vectors (MMVs) to further improve source retrieval performance. We show its superiority compared to the original formulation and demonstrate its ability to correctly estimate both the sources' location and their magnitude. Finally evidence is given of the high performance of the proposed algorithm compared to other MMV models.

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Authors: Hansen, S. T. (Intern), Stahlhut, C. (Intern), Hansen, L. K. (Intern)
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FindZebra: A search engine for rare diseases

Background: The web has become a primary information resource about illnesses and treatments for both medical and non-medical users. Standard web search is by far the most common interface for such information. It is therefore of interest to find out how well web search engines work for diagnostic queries and what factors contribute to successes and failures. Among diseases, rare (or orphan) diseases represent an especially challenging and thus interesting class to diagnose as each is rare, diverse in symptoms and usually has scattered resources associated with it.

Methods: We use an evaluation approach for web search engines for rare disease diagnosis which includes 56 real life diagnostic cases, state-of-the-art evaluation measures, and curated information resources. In addition, we introduce FindZebra, a specialized (vertical) rare disease search engine. FindZebra is powered by open source search technology and uses curated freely available online medical information.

Results: FindZebra outperforms Google Search in both default setup and customised to the resources used by FindZebra. We extend FindZebra with specialized functionalities exploiting medical ontological information and UMLS medical concepts to demonstrate different ways of displaying the retrieved results to medical experts.

Conclusions: Our results indicate that a specialized search engine can improve the diagnostic quality without compromising the ease of use of the currently widely popular web search engines. The proposed evaluation approach can be valuable for future development and benchmarking. The FindZebra search engine is available at http://www.findzebra.com/.

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Authors: Dragusin, R. (Forskerdatabase), Petcu, P. (Ekstern), Lioma, C. A. (Intern), Larsen, B. (Ekstern), Jørgensen, H. H. (Forskerdatabase), Cox, I. (Intern), Hansen, L. K. (Intern), Ingwersen, P. (Ekstern), Winther, O. (Intern)
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Hearing Aid Personalization

Modern digital hearing aids require and offer a great level of personalization. Today, this personalization is not performed based directly on what the user actually perceives, but on a hearing-care professional’s interpretation of what the user
explains about what is perceived. In this paper, an interactive personalization system based on Gaussian process regression and active learning is proposed, which personalize the hearing aids based directly on what the user perceives. Preliminary results demonstrate a significant difference between a truly personalized setting obtained with the proposed system and a setting obtained by the current practice.

How about a Bayesian M/EEG imaging method correcting for incomplete spatio-temporal priors
In this contribution we present a hierarchical Bayesian model, sAquavit, to tackle the highly ill-posed problem that follows with MEG and EEG source imaging. Our model facilitates spatio-temporal patterns through the use of both spatial and temporal basis functions. While in contrast to most previous spatio-temporal inverse M/EEG models, the proposed model benefits of consisting of two source terms, namely, a spatio-temporal pattern term limiting the source configuration to a spatio-temporal subspace and a source correcting term to pick up source activity not covered by the spatio-temporal prior belief.

We have tested the model on both artificial data and real EEG data in order to demonstrate the efficacy of the model. The model was tested at different SNRs (-10.0,-5.2, -3.0, -1.0, 0, 0.8, 3.0 dB) using white noise. At all SNRs the sAquavit performs best in AUC measure, e.g. at SNR=0dB AUC is, 0.985 (sAquavit) and 0.857 (Bolstad et al., 2009).

Our results demonstrate that the sAquavit model is capable in balancing spatio-temporal prior guidance and source correction estimation to obtain superior estimates relative to current inverse methods.
How low can you go: Spatial frequency sensitivity in a patient with pure alexia

Pure alexia is a selective deficit in reading, following lesions to the posterior left hemisphere. Writing and other language functions remain intact in these patients. Whether pure alexia is caused by a primary problem in visual perception is highly debated. A recent hypothesis suggests that a low level deficit – reduced sensitivity to particular spatial frequencies – is the underlying cause. We tested this hypothesis in a pure alexic patient (LK), using a sensitive psychophysical paradigm to examine her performance with simple patterns of different spatial frequency. We find that both in a detection and a classification task, LK's contrast sensitivity is comparable to normal controls for all spatial frequencies. Thus, reduced spatial frequency sensitivity does not constitute a general explanation for pure alexia, suggesting that the core deficit in this disorder is at a higher level in the visual processing stream.
Images from a jointly-arousing collective ritual reveal affective polarization

Collective rituals are biologically ancient and culturally pervasive, yet few studies have quantified their effects on participants. We assessed two plausible models from qualitative anthropology: ritual empathy predicts affective convergence among all ritual participants irrespective of ritual role; rite-of-passage predicts emotional differences, specifically that ritual initiates will express relatively negative valence when compared with non-initiates. To evaluate model predictions, images of participants in a Spanish fire-walking ritual were extracted from video footage and assessed by nine Spanish raters for arousal and valence. Consistent with rite-of-passage predictions, we found that arousal jointly increased for all participants but that valence differed by ritual role: fire-walkers exhibited increasingly positive arousal and increasingly negative valence when compared with passengers. This result offers the first quantified evidence for rite of passage dynamics within a highly arousing collective ritual. Methodologically, we show that surprisingly simple and non-
invasive data structures (rated video images) may be combined with methods from evolutionary ecology (Bayesian Generalized Linear Mixed Effects models) to clarify poorly understood dimensions of the human condition.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Victoria University of Wellington, Masaryk University, Aarhus University, Universidad Complutense, University of Auckland
Authors: Bulbulia, J. (Ekstern), Xygalatas, D. (Ekstern), Schjoedt, U. (Ekstern), Fondevila, S. (Ekstern), Sibley, C. G. (Ekstern), Konvalinka, I. (Intern)
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Kernel Methods for Machine Learning with Life Science Applications
Kernel methods refer to a family of widely used nonlinear algorithms for machine learning tasks like classification, regression, and feature extraction. By exploiting the so-called kernel trick straightforward extensions of classical linear algorithms are enabled as long as the data only appear as innerproducts in the model formulation. This dissertation presents research on improving the performance of standard kernel methods like kernel Principal Component Analysis
and the Support Vector Machine. Moreover, the goal of the thesis has been two-fold.

The first part focuses on the use of kernel Principal Component Analysis for nonlinear denoising. In this context stable solution of the inverse and inherently ill-posed pre-image problem constitutes the main challenge. It is proposed to stabilize the estimation by augmenting the cost function with either an ’1-or ’2-norm penalty, and solution schemes are derived for both approaches. The methods are experimentally validated on several biomedical data sets. Furthermore, frameworks for exploiting label information for improved denoising in the semisupervised case are proposed.

The second part of the thesis examines the effect of variance inflation in kernel methods. Variance inflation occurs in high-dimensional problems when the training data are insufficient to describe the entire signal manifold. Thereby leading to a potential mismatch between the subspaces spanned by the training and test data, respectively. It is shown how this effect extends from linear models to kernel learning, and means for restoring the generalizability in both kernel Principal Component Analysis and the Support Vector Machine are proposed. Viability is proved on a wide range of benchmark machine learning data sets.

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Feature extraction and dimensionality reduction are important tasks in many fields of science dealing with signal processing and analysis. The relevance of these techniques is increasing as current sensory devices are developed with ever higher resolution, and problems involving multimodal data sources become more common. A plethora of feature extraction methods are available in the literature collectively grouped under the field of multivariate analysis (MVA). This article provides a uniform treatment of several methods: principal component analysis (PCA), partial least squares (PLS), canonical correlation analysis (CCA), and orthonormalized PLS (OPLS), as well as their nonlinear extensions derived by means of the theory of reproducing kernel Hilbert spaces (RKHSs). We also review their connections to other methods for classification and statistical dependence estimation and introduce some recent developments to deal with the extreme cases of large-scale and low-sized problems. To illustrate the wide applicability of these methods in both classification and regression problems, we analyze their performance in a benchmark of publicly available data sets and pay special attention to specific real applications involving audio processing for music genre prediction and hyperspectral satellite image processing for Earth and climate monitoring.

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Ratings:
Large scale inference in the Infinite Relational Model: Gibbs sampling is not enough

The stochastic block-model and its non-parametric extension, the Infinite Relational Model (IRM), have become key tools for discovering group-structure in complex networks. Identifying these groups is a combinatorial inference problem which is usually solved by Gibbs sampling. However, whether Gibbs sampling suffices and can be scaled to the modeling of large scale real world complex networks has not been examined sufficiently. In this paper we evaluate the performance and mixing ability of Gibbs sampling in the Infinite Relational Model (IRM) by implementing a high performance Gibbs sampler. We find that Gibbs sampling can be computationally scaled to handle millions of nodes and billions of links. Investigating the behavior of the Gibbs sampler for different sizes of networks we find that the mixing ability decreases drastically with the network size, clearly indicating a need for better sampling strategies.
Large-scale Machine Learning in High-dimensional Datasets

Over the last few decades computers have gotten to play an essential role in our daily life, and data is now being collected in various domains at a faster pace than ever before. This dissertation presents research advances in four machine learning fields that all relate to the challenges imposed by the analysis of big data.

In the field of kernel methods, we present an information-based denoising technique based on semi-supervised kernel Principal Component Analysis (PCA), that incorporates label information into the kernel PCA objective. Effectively, this guides the low-rank representation towards relevant components, while exploiting intrinsic manifold structures exposed by the data. In the same field, we also introduce a scalable randomized heuristic for optimizing kernel hyperparameters, that is based on maximizing the Minimum Enclosing Ball (MEB) of the class means in the associated Reproducing Kernel Hilbert Space (RKHS).

In the field of spectral methods, we introduce semi-supervised eigenvectors of a graph Laplacian, that inherit many of the properties that characterize the global eigenvectors, but by using side-information in the form of a seed set, the semi-supervised eigenvectors are better at modeling local heterogeneities.

In the field of machine learning for neuroimaging, we introduce learning protocols for real-time functional Magnetic Resonance Imaging (fMRI) that allow for dynamic intervention in the human decision process. Specifically, the model exploits the structure of fMRI data by incorporating a temporal Gaussian Process (GP) smoothness prior, which reduces model degeneracy caused by mislabeled data samples.

Finally, in the field of topic modeling, we introduce a Graphics Processing Unit (GPU) accelerated framework for co-clustering in large-scale sparse bipartite networks. By implementing the Infinite Relational Model (IRM) in this framework we achieve speedups of two orders of magnitude compared to estimation based on conventional processors.
Learning the solution sparsity of an ill-posed linear inverse problem with the Variational Garrote

The Variational Garrote is a promising new approach for sparse solutions of ill-posed linear inverse problems (Kappen and Gomez, 2012). We reformulate the prior of the Variational Garrote to follow a simple Binomial law and assign a Beta hyper-prior on the parameter. With the new prior the Variational Garrote, we show, has a wide range of parameter values for which it at the same time provides low test error and high retrieval of the true feature locations. Furthermore, the new form of the prior and associated hyper-prior leads to a simple update rule in a Bayesian variational inference scheme for its hyperparameter. As a second contribution we provide evidence that the new procedure can improve on cross-validation of the parameters and we find that the new formulation of the prior outperforms the original formulation when both are cross-validated to determine hyperparameters.

Les risques industriels et le prix des logements

Le prix des logements peut diminuer du fait de la proximité d’installations industrielles. Cet effet dépend de la perception du risque par les riverains et est donc potentiellement modifié par des événements changeant la perception du risque, tels que les plans de prévention des risques technologiques en France. L’impact de ces plans est difficile à estimer, car les plans mis en œuvre en zones urbanisées sont récents. Cependant, l’analyse d’autres événements modifiant la perception du risque permet d’apporter des premiers éléments de réponse. Les trois zones urbanisées étudiées sont situées à proximité d’installations industrielles dans les agglomérations françaises de Bordeaux, Dunkerque et Rouen. La méthode des prix hédoniques permet d’estimer l’effet de la proximité des usines sur les prix des logements. Les résultats suggèrent que les écarts de prix ne sont modifiés ni par les incidents locaux, ni par la catastrophe d’AZF, ni par les dispositifs d’information, ni par la mise en place du régime d’assurance des catastrophes technologiques.
Measuring Personalization of Web Search

Web search is an integral part of our daily lives. Recently, there has been a trend of personalization in Web search, where different users receive different results for the same search query. The increasing personalization is leading to concerns about Filter Bubble effects, where certain users are simply unable to access information that the search engines' algorithm decides is irrelevant. Despite these concerns, there has been little quantification of the extent of personalization in Web search today, or the user attributes that cause it. In light of this situation, we make three contributions. First, we develop a methodology for measuring personalization in Web search results. While conceptually simple, there are numerous details that our methodology must handle in order to accurately attribute differences in search results to personalization. Second, we apply our methodology to 200 users on Google Web Search; we find that, on average, 11.7% of results show differences due to personalization, but that this varies widely by search query and by result ranking. Third, we investigate the causes of personalization on Google Web Search. Surprisingly, we only find measurable personalization as a result of searching with a logged in account and the IP address of the searching user. Our results are a first step towards understanding the extent and effects of personalization on Web search engines today.
under quasi-natural conditions. Challenges related to the ill-posed nature of the EEG imaging problem escalate in mobile real-time systems and new algorithms and the use of meta-data may be necessary to succeed. Based on recent work (Delorme et al., 2011) we hypothesize that solutions of interest are sparse. We propose a new Markovian prior for temporally sparse solutions and a direct search for sparse solutions as implemented by the so-called “variational garrote” (Kappen, 2011). We show that the new prior and inference scheme leads to improved solutions over competing sparse Bayesian schemes based on the “multiple measurement vectors” approach.

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Authors: Hansen, L. K. (Intern), Hansen, S. T. (Intern), Stahlhut, C. (Intern)
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Modeling Temporal Evolution and Multiscale Structure in Networks
Many real-world networks exhibit both temporal evolution and multiscale structure. We propose a model for temporally correlated multifurcating hierarchies in complex networks which jointly capture both effects. We use the Gibbs fragmentation tree as prior over multifurcating trees and a change-point model to account for the temporal evolution of each vertex. We demonstrate that our model is able to infer time-varying multiscale structure in synthetic as well as three real world time-evolving complex networks. Our modeling of the temporal evolution of hierarchies brings new insights into the changing roles and position of entities and possibilities for better understanding these dynamic complex systems.

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Authors: Herlau, T. (Intern), Mørup, M. (Intern), Schmidt, M. N. (Intern)
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Modelling auditory attention: Insights from the Theory of Visual Attention (TVA)
We report initial progress towards creating an auditory analogue of a mathematical model of visual attention: the ‘Theory of Visual Attention’ (TVA; Bundesen, 1990). TVA is one of the best established models of visual attention. It assumes that
visual stimuli are initially processed in parallel, and that there is a ‘race’ for selection and representation in visual short term memory (VSTM). In the basic TVA task, participants view a brief display of letters and are asked to report either all of the letters (whole report) or a subset of the letters (e.g., the red letters; partial report). Fitting the model to the data produces the following parameters: the minimum amount of information required for target identification \(t_0\); the rate at which information is encoded, assuming an exponential function \(v\); the relative attentional weight to targets versus distractors \(\alpha\); and the capacity of VSTM \(K\). TVA has been used to model normal visual attention, as well as identifying how the different parameters are affected by changes across the lifespan (McAvinue et al., 2012) and by attentional deficits such as neglect (Duncan et al., 1999). An auditory analogue would allow these same parameters to be measured for auditory attention; providing insights into impaired auditory attention in old adults and neuropsychological patients, and allowing direct comparisons with visual attention.

In the visual task, the stimuli are simultaneous, stationary (unchanging over time), and separated in space. In the first instance we are testing whether TVA can model identification of auditory stimuli with the same characteristics. The task is to identify dichotic, concurrently-presented synthesised vowels with different f0s. Early data indicate that the rate of information acquisition is more rapid for auditory stimuli, and may be better modelled using a log-logistic function than an exponential function. A more challenging difference is that in the partial report task, there is more target-distractor confusion for auditory than visual stimuli. This failure of object-formation (prior to attentional object-selection) is not yet effectively modelled by TVA.

**Mouth reversal extinguishes mismatch negativity induced by the McGurk illusion**

The sight of articulatory mouth movements (visual speech) influences auditory speech perception. This is demonstrated by the McGurk illusion in which incongruent visual speech alters the auditory phonetic percept. In behavioral studies, reversal of the vertical mouth direction has been reported to greatly reduce the McGurk illusion (Rosenblum et al., 2000). Such findings support the idea that audiovisual integration in speech to some extent relies on information regarding facial configuration. Here we ask whether this behavioral effect is reflected in a difference in neural activity in the auditory cortex. Mismatch Negativity (MMN) is a component in the auditory Event-Related Potential (ERP) that is elicited by a change in the auditory percept. It has been shown that the McGurk illusion can induce a MMN. We conducted an experiment in which the MMN could be elicited by the McGurk illusion induced by visual speech with either upright (unaltered) or vertically reversed mouth area. In a preliminary analysis, we found a Mismatch Negativity component induced by the McGurk illusion for 6 of 17 participants at electrode Cz when the mouth area was upright. In comparison, these participants produced no Mismatch Negativity when the mouth was reversed. These findings mirrored behavioral findings in the same subjects of a strong McGurk response for normal audiovisual speech, which was greatly reduced for stimuli with reversed mouth area.
Multiple sclerosis impairs regional functional connectivity in the cerebellum

Resting-state functional magnetic resonance imaging (rs-fMRI) has been used to study changes in long-range functional brain connectivity in multiple sclerosis (MS). Yet little is known about how MS affects functional brain connectivity at the local level. Here we studied 42 patients with MS and 30 matched healthy controls with whole-brain rs-fMRI at 3 T to examine local functional connectivity. Using the Kendall's Coefficient of Concordance, regional homogeneity of blood-oxygen-level-dependent (BOLD)-signal fluctuations was calculated for each voxel and used as a measure of local connectivity. Patients with MS showed a decrease in regional homogeneity in the upper left cerebellar hemisphere in lobules V and VI relative to healthy controls. Similar trend changes in regional homogeneity were present in the right cerebellar hemisphere. The results indicate a disintegration of regional processing in the cerebellum in MS. This might be caused by a functional disruption of cortico-ponto-cerebellar and spino-cerebellar inputs, since patients with higher lesion load in the left cerebellar peduncles showed a stronger reduction in cerebellar homogeneity. In patients, two clusters in the left posterior cerebellum expressed a reduction in regional homogeneity with increasing global disability as reflected by the Expanded Disability Status Scale (EDSS) score or higher ataxia scores. The two clusters were mainly located in Crus I and extended into Crus II and the dentate nucleus but with little spatial overlap. These findings suggest a link between impaired regional integration in the cerebellum and general disability and ataxia.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital
Authors: Dogonowski, A. (Ekstern), Andersen, K. W. (Intern), Madsen, K. H. (Intern), Sørensen, P. S. (Forskerdatabase), Paulson, O. B. (Ekstern), Blinkenberg, M. (Ekstern), Siebner, H. R. (Ekstern)
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Nanomechanical recognition of prognostic biomarker suPAR with DVD-ROM optical technology

In this work the use of a high-throughput nanomechanical detection system based on a DVD-ROM optical drive and cantilever sensors is presented for the detection of urokinase plasminogen activator receptor inflammatory biomarker (uPAR). Several large scale studies have linked elevated levels of soluble uPAR (suPAR) to infectious diseases, such as HIV, and certain types of cancer. Using hundreds of cantilevers and a DVD-based platform, cantilever deflection response from antibody–antigen recognition is investigated as a function of suPAR concentration. The goal is to provide a cheap and portable detection platform which can carry valuable prognostic information. In order to optimize the cantilever response the antibody immobilization and unspecific binding are initially characterized using quartz crystal microbalance technology. Also, the choice of antibody is explored in order to generate the largest surface stress on the cantilevers, thus increasing the signal. Using optimized experimental conditions the lowest detectable suPAR concentration is currently around 5 nM. The results reveal promising research strategies for the implementation of specific biochemical assays in a portable and high-throughput microsensor-based detection platform.
Nonparametric Bayesian Modeling of Complex Networks: An Introduction

Modeling structure in complex networks using Bayesian nonparametrics makes it possible to specify flexible model structures and infer the adequate model complexity from the observed data. This article provides a gentle introduction to nonparametric Bayesian modeling of complex networks: Using an infinite mixture model as running example, we go through the steps of deriving the model as an infinite limit of a finite parametric model, inferring the model parameters by Markov chain Monte Carlo, and checking the model’s fit and predictive performance. We explain how advanced nonparametric models for complex networks can be derived and point out relevant literature.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Schmidt, M. N. (Intern), Mørup, M. (Intern)
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Participatory Bluetooth Sensing: A Method for Acquiring Spatio-Temporal Data about Participant Mobility and Interactions at Large Scale Events

Acquisition of data to capture human mobility and interactions during large-scale events is a challenging task. In this paper we discuss a mobile sensing method for mapping the mobility of crowds at large scale events using a participatory
Bluetooth sensing approach. This non-invasive technique for collecting spatio-temporal data about participant mobility and social interactions uses the capabilities of Bluetooth capable smartphones carried by participants. As a proof-of-concept we present a field study with deployment of the method in a large music festival with 130 000 participants where a small subset of participants installed Bluetooth sensing apps on their personal smartphones. Our software module uses location and Bluetooth scans to utilize smartphones as provisional scanners that are present with higher frequency in regions with high density of participants. We discuss the initial results obtained and outline opportunities and challenges introduced by this methodology along with opportunities for future pervasive systems and applications.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark
Authors: Stopczynski, A. (Intern), Larsen, J. E. (Intern), Jørgensen, S. L. (Intern), Dynowski, L. (Ekstern), Fuentes, M. (Ekstern)
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BFI conference series: IEEE International Conference on Pervasive Computing and Communications (5000547)
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**Personal Informatics in the Wild: Hacking Habits for Health & Happiness**

Personal informatics is a class of systems that help people collect personal information to improve selfknowledge. Improving self-knowledge can foster selfinsight and promote positive behaviors, such as healthy living and energy conservation. The development of personal informatics applications poses new challenges in human-computer interaction and creates opportunities for applications in various domains related to quality of life, such as fitness, nutrition, wellness, mental health, and sustainability. This workshop will continue the conversations from the 3 previous CHI workshops [6][7][8] through discussions on practical lessons from previous research and development experiences. In particular, this workshop will extend this ongoing work through a focus on rapid prototyping and deployment in the wild. Topics covered will include designing interfaces for collecting and reflecting on personal data, building robust applications, and infrastructures to make applications easier to create.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Google, University of Maryland, Georgia Institute of Technology, University of California
Authors: Li, I. (Ekstern), Froehlich, J. (Ekstern), Larsen, J. E. (Intern), Grevet, C. (Ekstern), Ramirez, E. (Ekstern)
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Personalized Audio Systems - a Bayesian Approach

Modern audio systems are typically equipped with several user-adjustable parameters unfamiliar to most users listening to the system. To obtain the best possible setting, the user is forced into multi-parameter optimization with respect to the user's own objective and preference. To address this, the present paper presents a general inter-active framework for personalization of such audio systems. The framework builds on Bayesian Gaussian process regression in which a model of the user's objective function is updated sequentially. The parameter setting to be evaluated in a given trial is selected by model-based sequential experimental design. A Gaussian process model is proposed which incorporates correlation among particular parameters providing better modeling capabilities compared to a standard model. A ve-band equalizer is considered for demonstration purposes, in which the parameters are optimized using the proposed framework. Twelve test subjects obtain a personalized setting with the framework, and these settings are significantly preferred to those obtained with random experimentation.

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Nielsen, J. B. (Intern), Jensen, B. S. (Intern), Hansen, T. J. (Intern), Larsen, J. (Intern)
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Perturbative corrections for approximate inference in gaussian latent variable models

Expectation Propagation (EP) provides a framework for approximate inference. When the model under consideration is over a latent Gaussian field, with the approximation being Gaussian, we show how these approximations can systematically be corrected. A perturbative expansion is made of the exact but intractable correction, and can be applied to the model's partition function and other moments of interest. The correction is expressed over the higher-order cumulants which are neglected by EP's local matching of moments. Through the expansion, we see that EP is correct to first order. By considering higher orders, corrections of increasing polynomial complexity can be applied to the approximation. The second order provides a correction in quadratic time, which we apply to an array of Gaussian process and Ising models. The corrections generalize to arbitrarily complex approximating families, which we illustrate on tree-structured Ising model approximations. Furthermore, they provide a polynomial-time assessment of the approximation error. We also provide both theoretical and practical insights on the exactness of the EP solution. © 2013 Manfred Opper, Ulrich Paquet and Ole Winther.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technische Universität Berlin, Microsoft Research Cambridge
Authors: Opper, M. (Ekstern), Paquet, U. (Ekstern), Winther, O. (Intern)
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BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 2.905 SJR 1.271
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.09 SJR 1.29 SNIP 2.143
We re-examined the issue of active versus passive proprioception to more fully characterize the accuracy afforded by proprioceptive information in natural, unconstrained, movements in 3-dimensions. Subjects made pointing movements with their non-dominant arm to various locations with eyes closed. They then proprioceptively localized the tip of its index finger with a prompt pointing movement of their dominant arm, thereby bringing the two indices in apposition. Subjects performed this task with remarkable accuracy. More remarkably, the same subjects were equally accurate at localizing the index finger when the arm was passively moved and maintained in its final position by an experimenter. Two subjects were also tested with eyes open, and they were no more accurate than with eyes closed. We also found that the magnitude of the error did not depend on movement duration, which is contrary to a key observation in support of the existence of an internal forward model-based state-reconstruction scheme. Three principal conclusions derive from this study. First, in unconstrained movements, proprioceptive information provides highly accurate estimates of limb position. Second, so-called active proprioception does not provide better estimates of limb position than passive proprioception. Lastly, in the active movement condition, an internal model-based estimation of limb position should, according to that hypothesis, have occurred throughout the movement. If so, it did not lead to a better estimate of final limb position, or lower variance of the estimate, casting doubt on the necessity to invoke this hypothetical construct.
Population Structure

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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, University of Copenhagen
Authors: Guillot, G. (Intern), Orlando, L. (Ekstern)
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PorkCAD: Case study of the design of a pork product prototyper
With the help of industry experts we developed porkCAD, an application intended to aid in the communication process between producer and retailer when developing new meat products for a constantly evolving market. The application interface allows the user to make planar cuts to a virtual pig formed from CT-scans of a real-world pig carcass. We present a case study of the design process from conceptualization to intended introduction into the work flow of a meat production company. We discuss critical design decisions during development and present perspectives for future development.

To determine the usability of porkCAD, we tested it with personnel from the pork industry, using two different controller interfaces, one being a traditional mouse and keyboard input, and the other a six degrees of freedom haptic feedback device. The accurate depiction of pig anatomy guided trained professionals to re-create standardized pig products using porkCAD. The quantitative results of the usability test with sales personnel did not lean significantly in favor of either interface.

Since one interface was extremely well known and the other highly unfamiliar, the fact that users did not express a clear preference for the known input modality is deemed important. We report on the observed user experience regarding the two interfaces.

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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Cognitive Systems, Statistics and Data Analysis, University of Tokyo, Danish Technological Institute
Authors: Laursen, L. F. (Intern), Bærentzen, J. A. (Intern), Igarashi, T. (Ekstern), Petersen, M. K. (Intern), Clemmensen, L. K. H. (Intern), Ersbøll, B. K. (Intern), Christensen, L. B. (Ekstern)
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Predictive Modeling of Expressed Emotions in Music Using Pairwise Comparisons

We introduce a two-alternative forced-choice (2AFC) experimental paradigm to quantify expressed emotions in music using the arousal and valence (AV) dimensions. A wide range of well-known audio features are investigated for predicting the expressed emotions in music using learning curves and essential baselines. We furthermore investigate the scalability issues of using 2AFC in quantifying emotions expressed in music on large-scale music databases. The possibility of dividing the annotation task between multiple individuals, while pooling individuals' comparisons is investigated by looking at the subjective differences of ranking emotion in the AV space. We find this to be problematic due to the large variation in subjects' rankings of excerpts. Finally, solving scalability issues by reducing the number of pairwise comparisons is analyzed. We compare two active learning schemes to selecting comparisons at random by using learning curves. We show that a suitable predictive model of expressed valence in music can be achieved from only 15% of the total number of comparisons when using the Expected Value of Information (EVOI) active learning scheme. For the arousal dimension we require 9% of the total number of comparisons.

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Scopus rating (2017): SJR 0.295 SNIP 0.655
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.67 SJR 0.339 SNIP 0.642
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.369 SNIP 0.684 CiteScore 0.37
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.354 SNIP 0.743 CiteScore 0.42
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.36 SNIP 0.761 CiteScore 0.49
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.346 SNIP 0.762 CiteScore 0.49
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.338 SNIP 0.765 CiteScore 0.49
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BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.322 SNIP 0.663
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.302 SNIP 0.576
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.277 SNIP 0.465
Scopus rating (2007): SJR 0.293 SNIP 0.513
Process optimization of ultrasonic spray coating of polymer films

In this work we have performed a detailed study of the influence of various parameters on spray coating of polymer films. Our aim is to produce polymer films of uniform thickness (500 nm to 1 μm) and low roughness compared to the film thickness. The coatings are characterized with respect to thickness, roughness (profilometer), and morphology (optical microscopy). Polyvinylpyrrolidone (PVP) is used to do a full factorial design of experiments with selected process parameters such as temperature, distance between spray nozzle and substrate, and speed of the spray nozzle. A mathematical model is developed for statistical analysis which identifies the distance between nozzle and substrate as the most significant parameter. Depending on the drying of the sprayed droplets on the substrate, we define two broad regimes, "dry" and "wet". The optimum condition of spraying lies in a narrow window between these two regimes, where we obtain a film of desired quality. Both with increasing nozzle-substrate distance and temperature, the deposition moves from a wet state to a dry regime. Similar results are also achieved for solvents with low boiling points. Finally, we study film formation during spray coating with poly (d,l-lactide) (PDLLA). The results confirm the processing knowledge obtained with PVP and indicate that the observed trends are identical for spraying of other polymer films. © 2013 American Chemical Society.
In this paper we propose an interactive visualization technique QS Spiral that aims to capture the periodic properties of quantified self data and let the user explore those recurring patterns. The approach is based on time-series data visualized as a spiral structure. The interactivity includes the possibility of varying the time span and the time frame shown, allowing for different levels of detail and the discoverability of repetitive patterns in the data on multiple scales. We illustrate the
Sequential collaboration network with sentiment coloring

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Authors: Nielsen, F. Å. (Intern)
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Sparse Source EEG Imaging with the Variational Garrote

EEG imaging, the estimation of the cortical source distribution from scalp electrode measurements, poses an extremely ill-posed inverse problem. Recent work by Delorme et al. (2012) supports the hypothesis that distributed source solutions are sparse. We show that direct search for sparse solutions as implemented by the Variational Garrote (Kappen, 2011) provides excellent estimates compared with other widely used schemes, is computationally attractive, and by its separation of ‘where’ and ‘what’ degrees of freedom paves the road for the introduction of genuine prior information.

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Authors: Hansen, S. T. (Intern), Stahlhut, C. (Intern), Hansen, L. K. (Intern)
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Spatio temporal media components for neurofeedback

A class of Brain Computer Interfaces (BCI) involves interfaces for neurofeedback training, where a user can learn to self-regulate brain activity based on real-time feedback. These particular interfaces are constructed from audio-visual components and temporal settings, which appear to have a strong influence on the ability to control brain activity. Therefore, identifying the different interface components and exploring their individual effects might be key for constructing new interfaces that support more efficient neurofeedback training. We discuss experiments involving two different designs of neurofeedback interfaces and suggest further research to clarify the influence of different audiovisual components and temporal settings on neurofeedback effect.

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Authors: Jensen, C. B. F. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern), Stahlhut, C. (Intern), Ivanova, M. G. (Intern), Andersen, T. (Intern), Hansen, L. K. (Intern)
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Surface-Enhanced Raman Spectroscopy Based Quantitative Bioassay on Aptamer-Functionalized Nanopillars Using Large-Area Raman Mapping

Surface-enhanced Raman spectroscopy (SERS) has been used in a variety of biological applications due to its high sensitivity and specificity. Here, we report a SERS-based biosensing approach for quantitative detection of biomolecules. A SERS substrate bearing gold-decorated silicon nanopillars is functionalized with aptamers for sensitive and specific detection of target molecules. In this study, TAMRA-labeled vasopressin molecules in the picomolar regime (1 pM to 1 nM) are specifically captured by aptamers on the nanostructured SERS substrate and monitored by using an automated SERS signal mapping technique. From the experimental results, we show concentration-dependent SERS responses in the picomolar range by integrating SERS signal intensities over a scanning area. It is also noted that our signal mapping approach significantly improves statistical reproducibility and accounts for spot-to-spot variation in conventional SERS quantification. Furthermore, we have developed an analytical model capable of predicting experimental intensity distributions on the substrates for reliable quantification of biomolecules. Lastly, we have calculated the minimum needed area of Raman mapping for efficient and reliable analysis of each measurement. Combining our SERS mapping analysis with an aptamer-functionalized nanopillar substrate is found to be extremely efficient for detection of low-abundance biomolecules.

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Authors: Yang, J. (Ekstern), Palla, M. (Ekstern), Bosco, F. (Intern), Rindzevicius, T. (Intern), Alstrøm, T. S. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Ju, J. (Ekstern), Lin, Q. (Ekstern)
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Towards a universal representation for audio information retrieval and analysis

A fundamental and general representation of audio and music which integrates multi-modal data sources is important for both application and basic research purposes. In this paper we address this challenge by proposing a multi-modal version of the Latent Dirichlet Allocation model which provides a joint latent representation. We evaluate this representation on the Million Song Dataset by integrating three fundamentally different modalities, namely tags, lyrics, and audio features. We show how the resulting representation is aligned with common 'cognitive' variables such as tags, and provide some evidence for the common assumption that genres form an acceptable categorization when evaluating latent representations of music. We furthermore quantify the model by its predictive performance in terms of genre and style, providing benchmark results for the Million Song Dataset.
This work presents a conceptual framework for learning an ontological structure of domain knowledge, which combines Jaccard similarity coefficient with the Infinite Relational Model (IRM) by (Kemp et al. 2006) and its extended model, i.e. the normal-Infinite Relational Model (n-IRM) by (Herlau et al. 2012). The proposed approach is applied to a dataset where legal concepts related to the Japanese educational system are defined by the Japanese authorities according to the International Standard Classification of Education (ISCED). Results indicate that the proposed approach effectively structures features for defining groups of concepts in several levels (i.e., concept, category, abstract category levels) from which an ontological structure is systematically visualized as a lattice graph based on the Formal Concept Analysis (FCA) by (Ganter and Wille 1997).

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Authors: Glückstad, F. K. (Ekstern), Herlau, T. (Intern), Schmidt, M. N. (Intern), Mørup, M. (Intern)
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Variance inflation in high dimensional Support Vector Machines

Many important machine learning models, supervised and unsupervised, are based on simple Euclidean distance or orthogonal projection in a high dimensional feature space. When estimating such models from small training sets we face the problem that the span of the training data set input vectors is not the full input space. Hence, when applying the model to future data the model is effectively blind to the missed orthogonal subspace. This can lead to an inflated variance of hidden variables estimated in the training set and when the model is applied to test data we may find that the hidden variables follow a different probability law with less variance. While the problem and basic means to reconstruct and deflate are well understood in unsupervised learning, the case of supervised learning is less well understood. We here investigate the effect of variance inflation in supervised learning including the case of Support Vector Machines (SVMS) and we propose a non-parametric scheme to restore proper generalizability. We illustrate the algorithm and its ability to restore performance on a wide range of benchmark data sets.
How Low Can You Go: Spatial Frequency Sensitivity in Pure Alexia

Objective: Pure alexia is a seemingly selective deficit in reading, following focal lesions to the posterior left hemisphere. The hallmark feature of pure alexia is a word length effect in single word reading, where reaction times may increase with hundreds of milliseconds per additional letter in a word. Other language functions, including writing, are intact. It has been suggested that pure alexia is caused by a general deficit in visual processing, one that affects reading disproportionally compared to other visual stimuli. The most concrete hypothesis to date suggests that pure alexia is caused by a lack of sensitivity to particular spatial frequencies (e.g., Fiset et al., 2006), and that this results in the characteristic word length effect, as well as effects of letter confusability on reading times.

Participants and Methods: We have tested this hypothesis in a patient with pure alexia (LK). LK shows significant effects of word length and letter confusability on reaction times in single word reading, while her writing and other language skills are intact. In two experiments, we investigate LK's performance with simple patterns of different spatial frequency (Gabor patches), and compare this to normal controls.

Results: We find that both in a detection and a classification paradigm, LK shows normal sensitivity for all spatial frequencies. Conclusions: On this basis we conclude that neither the word length effect, nor the effect of letter confusability on reading times, can be explained by a lack of sensitivity to particular spatial frequencies. Thus, the explanation for the reading performance of patients with pure alexia is likely to be found at a higher level of processing.
Integration of top-down and bottom-up information for audio organization and retrieval

The increasing availability of digital audio and music calls for methods and systems to analyse and organize these digital objects. This thesis investigates three elements related to such systems focusing on the ability to represent and elicit the user's view on the multimedia object and the system output. The aim is to provide organization and processing, which aligns with the understanding and needs of the users.

Audio and music is often characterized by the large amount of heterogenous information. The first aspect investigated is the integration of such multi-variate and multi-modal information sources based on latent Dirichlet allocation (LDA). The model is used to integrate bottom-up features (reflecting timbre, loudness, tempo and chroma), meta-data aspects (lyrics) and top-down aspects, namely user generated open vocabulary tags. The model and representation is evaluated on the auxiliary task of genre and style classification.

Eliciting the subjective representation and opinion of users is an important aspect in building personalized systems. The thesis contributes with a setup for modelling and elicitation of preference and other cognitive aspects with focus on audio applications. The setup is based on classical regression and choice models placed in the framework of Gaussian processes, which provides flexible non-parametric Bayesian models. The setup consist of a number of likelihood functions suitable for modelling both absolute ratings (direct scaling) and comparative judgements (indirect scaling). Inference is performed by analytical and simulation based methods, including the Laplace approximation and expectation propagation. In order to minimize the cost of the often expensive and lengthy experimentation, sequential experiment design or active learning is supported. The setup is applied in the field of music emotion modelling and optimization of a parametric audio system with high-dimensional input spaces.

The final aspect, considered in the thesis, concerns the general context of users, such as location and social context. This is important in understanding user behavior and in determining the users current information needs. The thesis investigates the predictability of the user context, in particular location, based on information theoretic bounds and a particular experimental approach based on context sensing using the ubiquitous mobile phone.

Joint Modelling of Structural and Functional Brain Networks

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

Many complex networks feature relations with weight information. Some models utilize this information while other ignore the weight information when inferring the structure. In this paper we investigate if edge-weights when modeling real networks, carry important information about the network structure. We compare five prominent models by their ability to predict links both in the presence and absence of weight information. In addition we quantify the models ability to account for the edge-weight information. We find that the complex models generally outperform simpler models when the task is to infer presence of edges, but that simpler models are better at inferring the actual weights.

Multi-colorimetric sensor array for detection of illegal materials

The detection of low pressure illegal compounds is an important analytical problem which requires reliable, selective and sensitive detection methods which provide the highest level of confidence in the result. Therefore, to contribute in the successful development of the recognition technology and signal processing enhancements to sensing methods, recognition ability, data acquisition time and data processing algorithms are necessary. In this research we work towards the development of a rapid, easy in use, highly sensitive, specific (minimal false positives) sensor based on a colorimetric sensing technology.
Semi-supervised Eigenvectors for Locally-biased Learning

In many applications, one has side information, e.g., labels that are provided in a semi-supervised manner, about a specific target region of a large data set, and one wants to perform machine learning and data analysis tasks "nearby" that pre-specified target region. Locally-biased problems of this sort are particularly challenging for popular eigenvector-based machine learning and data analysis tools. At root, the reason is that eigenvectors are inherently global quantities. In this paper, we address this issue by providing a methodology to construct semi-supervised eigenvectors of a graph Laplacian, and we illustrate how these locally-biased eigenvectors can be used to perform locally-biased machine learning. These semi-supervised eigenvectors capture successively-orthogonalized directions of maximum variance, conditioned on being well-correlated with an input seed set of nodes that is assumed to be provided in a semi-supervised manner. We also provide several empirical examples demonstrating how these semi-supervised eigenvectors can be used to perform locally-biased learning.

String matching with variable length gaps

We consider string matching with variable length gaps. Given a string $T$ and a pattern $P$ consisting of strings separated by variable length gaps (arbitrary strings of length in a specified range), the problem is to find all ending positions of substrings in $T$ that match $P$. This problem is a basic primitive in computational biology applications. Let $m$ and $n$ be the lengths of $P$ and $T$, respectively, and let $k$ be the number of strings in $P$. We present a new algorithm achieving time $O(n \log k + m + \alpha)$ and space $O(m + A)$, where $A$ is the sum of the lower bounds of the lengths of the gaps in $P$ and $\alpha$ is the total number of occurrences of the strings in $P$ within $T$. Compared to the previous results this bound essentially achieves the best known time and space complexities simultaneously. Consequently, our algorithm obtains the best known bounds for almost all combinations of $m$, $n$, $k$, $A$, and $\alpha$. Our algorithm is surprisingly simple and straightforward to implement. We also present algorithms for finding and encoding the positions of all strings in $P$ for every match of the pattern.
**Demonstration: A smartphone 3D functional brain scanner**

We demonstrate a fully portable 3D real-time functional brain scanner consisting of a wireless 14-channel 'Neuroheadset' (Emotiv EPOC) and a Nokia N900 smartphone. The novelty of our system is the ability to perform real-time functional brain imaging on a smartphone device, including stimulus delivery, data acquisition, logging, brain state decoding, and 3D visualization of the cortical EEG sources. Custom-made software realized in Qt has been implemented on the phone, which allow for either the phone to process the EEG data locally or transmit it to a server when more advanced machine learning tools are preferred. Source localization is implemented locally on the phone with a 3D brain model consisting of 1,028 vertices and 2,048 triangles stored in the mobile application.

Our system design benefits from the possibility of being able to integrate with multiple hardware platforms (smartphones, tablet computers, and netbooks) that are based on Linux operating systems.

**General information**

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Authors: Stahlhut, C. (Intern), Stopczynski, A. (Intern), Larsen, J. E. (Intern), Petersen, M. K. (Intern), Hansen, L. K. (Intern)
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