SPMS 2017

Stochastic and Physical Monitoring Systems

Book of abstracts of the 8th international conference SPMS2017

June 19 - June 23, 2017, Sokol Dobřichovice, Czech Republic

Organized by the Group of Applied Mathematics and Stochastics (GAMS),
Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University in Prague

Supported by the CTU SGS project SVK 26/17/F4

Foreword

Dear Colleagues,
it is our pleasure to welcome you to the 8^{th} STOCHASTIC & PHYSICAL MONITORING SYSTEMS.

The SPMS 2017 conference is held for the eighth time with the aim to bring together students and researchers with areas of interest related to the following topics: Analysis of microscopical structure of vehicular traffic streams and traffic modeling, Monitoring and classification of acoustic signals in material defectoscopy, New statistical distances and informational divergences with applications in acoustic emission, Small area estimation of geographical characteristics gained from data sets, and Data processing in high energy particle physics, which are all together briefly called Stochastic and Physical Monitoring Systems (SPMS). The conference links both the informal character of lively student meeting and the unique platform for the research presentations and discussions of the conference participants.

The meeting is organized by the Group of Applied Mathematics and Stochastics, Department of Mathematics, Czech Technical University in Prague and this year's venue is Sokol Dobřichovice is just a stone's throw from Prague, close to one of the most famous Czech castle, Karlštejn and has many sports facilities.

Local Organizing Committee:

Jiří Franc, Marek Bukáček, Václav Kůs (Chair).

Scientific and Program Committee:

Václav Kůs, Tomáš Hobza, Pavel Hrabák.

Invited Speakers:

Domingo Morales	- Universidad Miguel Hernández de Elche, Spain,
Milan Chlada	- IT, Czech Academy of Sciences, Prague, Czech Republic,
Zdeněk Převorovský	- IT, Czech Academy of Sciences, Prague, Czech Republic.
Jiří Grim	- UTIA, Czech Academy of Science, Prague, Czech Republic,
Vladislav Šimák	- FNSPE, Czech Technical University, Prague, Czech Republic.

We gratefully acknowledge the institutional support provided by the funds of specific research, namely by the SGS grant SVK 26/17/F4.

The Organizers

Contents

Deep Learning at NOvA

Petr Bouř

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: petr.bour@seznam.cz

Abstract

With the raise of modern computing capabilities and new approaches in deep learning, we are able to design convolutional neural networks suitable for purposes of particle identification at NOvA Experiment in Fermilab. Utilizing deep learning techniques leads to the significant increase in signal efficiency classification. We provide an overview of the experiment setup, raw data measurements and application of convolutional visual network.

Key words: convolutional neural networks, neutrino

Modelling of customer arrivals into the reservation system with stochastic processes

Viktor Brada

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: frequent.mistake@gmail.com

Abstract

A prediction of demand is very important in the field of a passenger transportation. The data garnered from the ticket reservation system allow for such a prediction. This work describes several methods for prediction, based on incomplete observations of the reservation process and its historical realisations. Discussed methods use random processes suitable for an estimation of the reservation process. Emphasis is placed on the Poisson process and the birth and death process. Furthermore, a model of reservation system is proposed, based on real data of one transportation company. This allows comparison of studied methods on real data and various simulated scenarios of demand. In conclusion, it is suggested which methods to use under the given conditions.

Key words: Poisson process, birth and death process, revenue management in transportation, stochastic process estimation, numerical simulations

Evaluation of pedestrian density distribution with respect to the velocity response

Marek Bukáček

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: marek.bukacek@seznam.cz

Abstract

There are many approaches to evaluate density within pedestrian scenarios, including point approximation, Voronoi cells or more sophisticated methods. In this project we focus on the individual density, where each pedestrian is considered as a source of density distribution. A cone with specific diameter can be considered as a reasonable shape, with its diameter as a blur parameter. Naturally, pedestrians adapt their velocity and path selection with respect to the conditions around them, let say in a given range. The correlation of density and velocity, respective density and exit angle was evaluated on laboratory experiment data for all acceptable blur – range combination. Because of negative correlation corresponds to more significant response of velocity (exit angle) to the density, the correlations seem to be perfect tool to estimate density parameters.

Key words: pedestrian dynamics, density distribution, correlations

Analysis of acoustic emission signals

Milan Chlada

Institute of Thermomechanics, Academy of Science, Prague, Czech republic

Email: chlada@it.cas.cz

Abstract

Acoustic emission (AE) systems provide continuous recording of high-frequency signals registered during longtime monitoring of various processes in materials. It can disclose the early damage phases (cracks) or certain imperfections and many other material defects. This method requires new signal processing and analysis approaches described in the paper.

Key words: Acoustic emission, signal analysis.

Area-level gamma mixed model

Ondřej Faltys

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: o.faltys@seznam.cz

Abstract

In practise we can encounter many problems where is useful (and sometimes necessary) to employ small area estimation (SAE) methods to obtain reliable estimates of characteristics of interest (means, totals, quantiles, etc.). The contribution deals with an area-level gamma mixed model that can be useful in some applications involving only positive responses (e.g. in a financial sector). To obtain estimates of regression parameters and predictors of random effects the PQL-algorithm and the ML Laplace approximation algorithm are introduced. In order to check the behaviour of the fitting algorithms we perform simulation experiments and compare acquired results of both of them.

Key words: Area-level model, generalized linear mixed model, pql-algorithm, maximum likelihood Laplace approximation algorithm

Consistency Study of Robustified Total Least Squares

Jiří Franc

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: jiri.franc@fjfi.cvut.cz

Abstract

The aim of this presentation is to introduce the properties of the correct estimation method in error-in-variables model if outliers in datasets occur. This robust version of the Total Least Squares (TLS) estimator is called Total Least Weighted Squares (TLWS). The concept of normal equations for TLS and its comparison with ridge regression and classical Gallo's approach is presented. Consistency of nonrubust TLS under different conditions is discussed and the consistency of TLWS is proved, along with large simulation study.

Key words: Total Least Squares (TLS), Total Least Weighted Squares (TLWS), consistency, simulations

Localization of acoustic emission via geodesic curves

Petr Gális

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: galispet@fjfi.cvut.cz

Abstract

We deal with the exact model of localization of acoustic emission (AE) sources on real complex solid bodies. Our approach is based on numerical computations of precise geodesic curves on 3D vessels which can be composed from several parametrized surfaces with multiple intersections. Instead of solving the geodesic differential equations under specific Christoffel symbols, we compute our geodesics numerically by Finite difference, NewtonâĂŞRaphson, and Fixed point iteration methods. For faster calculations we propose technical improvements and optimizations. We also consider the case when the surface contains the holes, i.e. the exact geodesic curve has to bypass a given obstacles. These techniques are used in real experiment on the galvanized steel watering can that represents a vessel with higher geometrical complexity. The layout of piezoelectric acoustic emission sensors supposes that the main part of the body can be inaccessible due to high temperature or radioactivity, such as in the case of nuclear power station health monitoring. Finally, we present the results of AE localization principle using length (or time) differences measured by means of geodesics found on the watering can while minimizing its distinctions from the real measured time differences.

Key words: Acoustic emission, non-destructive defectoscopy, geodesic curves, parametrized surfaces, Δt - exact localization

MIXTURES OF PRODUCT COMPONENTS: A TUTORIAL

Jiří Grim

Institute of Informarion Theory and Automation, Academy of Science, Prague, Czech republic

Email: grim@utia.cas.cz

Abstract

In literature the references to EM estimation of product mixtures are not very frequent. The simplifying assumption of product components, e.g. diagonal covariance matrices in case of Gaussian mixtures, is usually considered only as a compromise because of some computational constraints or limited data set. We have found that the product mixtures are rarely used intentionally as a preferable approximating tool. Probably, most practitioners do not "trust" the product components because of their formal similarity to

"naive Bayes models". Another reason could be an unrecognized numerical instability of EM algorithm in multidimensional spaces. In this paper we recall that the product mixture model does not imply the assumption of independence of variables. It is even not restrictive if the number of components is large enough. In addition, the product components increase numerical stability of the standard EM algorithm, simplify the EM iterations and have some other important advantages. We discuss and explain the implementation details of EM algorithm and summarize our experience in estimating product mixtures. Finally we illustrate the wide applicability of product mixtures in pattern recognition and in other fields.

Key words: Multivariate statistics, product mixtures, EM algorithm

---

Logistic mixed models for poverty incidence estimation

Tomáš Hobza

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: hobza@fjfi.cvut.cz

Abstract

This contribution deals with empirical best predictors (EBPs) and plug-in estimators of small area proportions under a unit-level logistic mixed model with independent time effects. The maximum likelihood estimates of the model parameters are obtained by maximizing the Laplace approximation to the model log-likelihood. The behavior of the introduced EBPs and plug-in estimators is studied by a Monte-Carlo simulation experiment. A procedure for bootstrap estimation of the mean squared errors is proposed. Finally, an application of the studied EBPs to data from the 2012 and 2013 Spanish living conditions surveys is presented. The target is the estimation of poverty incidences and their inter-annual variations in counties of the region of Valencia.

Key words: Small area estimation, poverty incedence, embirical best predictor, logistic mixed model

Mass transport processes and bottleneck flow

Pavel Hrabák

Faculty of Information Technology of the Czech Technical University in Prague, Czech Republic

Email: pavel.hrabak@fit.cvut.cz

Abstract

The usage of mass transport processes in pedestrian flow modelling is discussed. Main focus is given to bottleneck flow, where jamming and clogging occurs. Some theoretical approaches are mentioned. The contribution gives among others the field overview.

Key words: mass transport processes, bottleneck flow, pedestrian dynamics

Variational Blind Source Separation in Remote Sensing

Karel Hybner

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: karel.hybner@gmail.com

Abstract

One of the issues in signal processing is the problem of source separation. This concerns the situation where the observed signal is composed of a number of unknown source signals. In case a little is known about those signals and their number, the task of retrieving them is widely known as emphblind source separation. Various methods of blind source separation exist. Here we present an approach using bayesian statistics, specifically method of emphvariational Bayes approximation. A straightforward way to determine the number of source signals appears to be one of the main advantages of this approach (emphautomatic relevance determination property). One of the areas of blind source separation use is a field of emphremote sensing. We propose two models for unmixing of hyperspectral remote-sensed data, inferred using variational Bayes approximation.

Key words: blind source separation, remote sensing, variational Bayes approximation

Cramer-Rao boundary for blind source separation

Václav Kautský

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: kautsvac@fjfi.cvut.cz

Abstract

This work deals with a derivation of the Cramer-Rao Boundary for a novel blind source separation method called Independent Component Extraction. The method focuses on extraction of one target non-Gaussian signal from a Gaussian mixture. Those assumptions are considered in calculations of the CRB. Besides the derivation of CRB, this work contains results from numerical experiments showing comparison of CRB and well known Interference-to-Signal ratio of various methods. Those results prove coincidence of the theory and simulations, that the CRB is the lower boundary. There are important findings based on the simulations, e.g. a detection of efficiency. There are some methods that seem to be non-efficient, despite they are based on maximum likelihood principle. The comparison of CRB and ISR detects deficiencies of the method. This can lead to the method enhancement.

Key words: Blind Separation, Cramer-Rao Boundary, Independent Component Extraction

Rotation moment invariants of vector fields

Jitka Kostková

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: kostkjit@fjfi.cvut.cz

Abstract

Vector field images are a type of multidimensional data arising from many engineering areas. This type of images differs significantly from standard graylevel and color images in several aspects. Hence, there is a need for automatic processing of vector fields from application areas, developing special methods and algorithms for vector fields is of great importance. A common task in vector field analysis is the detection of various patterns of interest, such as sinks, vortices, saddle points, and others. The detection of these features is typically accomplished by template matching. The search algorithms must be primarily invariant to total rotation, where the action is applied not only on the spatial coordinates but also on the field values. Moment invariants of vector fields will be introduced. The superiority of orthogonal polynomials for construction of moments will be demonstrated. Their numerical stability will

be shown to be higher than of the invariants published so far. The usefulness of invariants constructed from orthogonal moments will be demonstrated in a real world template matching application.

Key words: Vector field, Total rotation, Invariants, Orthogonal polynomials

---

Comparison of methods for generalized linear mixed models parameters estimation

Tomáš Košlab

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: koslatom@fjfi.cvut.cz

Abstract

During the last few years generalized linear mixed models have been increasingly used to solve a large variety of problems ranging from medical research to insurance. GLMMs are an extension of generalized linear models that contain both fixed and random effects (hence mixed models). After the idea of these models is presented, the logistic regression model, which is a member of this group of models that is used in small area estimation, is focused on. Two methods of parameter estimation are used âĂŞ the EM algorithm and the PQL method - and they are compared by means of a simulation experiment. The properties of parameter estimates obtained by the respective methods is then studied with respect to increasing data contamination.

Key words: generalized linear mixed models, logistic regression, EM algorithm, PQL method

---

When Spacing Correlation Comes Into Play

Ondřej Kollert

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: ondra.kollert@gmail.com

Abstract

One-dimensional systems with repulsively interacting elements can possess various forms of dependency structures in terms of spacings between the elements. The simplest structure, where the spacings are independent, can be conveniently described by the standard methods of counting process theory. Nevertheless, this is not the case for most of real application systems where the one-dimensional elements can be represented for example by random matrix eigenvalues, times of event occurrences or spatial

locations of agents. Namely, such systems show extraordinarily complex dependencies where even farther spacings might be correlated. In that situation, the analytical solution is difficult, rather impossible to obtain. Some of the preliminary observations of such cases are provided in the given presentation. The results are mainly shown on the asymptotic behavior of advanced quantities called rigidity and corigidity.

Key words: Spacing Correlation, Repulsive Interaction, Random Eigenvalues, Rigidity, Corigidity

---

Index evaluation by means of Preisach-Mayergoyz space identification

Colette Kožená

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: kozena.colette@gmail.com

Abstract

Statistical Presiach-Mayergoyz model (PM model) of hysteresis can be used to characterize the nonlinear mechanical properties of hysteresis materials. PM model can be expressed as a weighted combination of relay operators (hysterons). Based on experimentaly measured data, new elasticity index IE and index of damage ID were designed. By means of identification the probability density of hysterons in PM space within a class of distribution mixtures through numerical optimization algorithm, the indexes of specific hystertic materials were evaluated.

Key words: Hysteresis, Distribution mixture, Preisach-Mayergoyz model, density identification, Elasticity index, Simulated Annealing

---

Actively-Followed Vehicles

Milan Krbálek

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: milan.krbalek@fjfi.cvut.cz

Abstract

We discuss a fundamental question of traffic modeling - question of authenticity of traffic models. In this paper we demonstrate that a generally-accepted premise (on a short range of traffic interactions) do not correspond to traffic reality. In contrast, we have determined (by means of Brownian distance-correlation instruments) that minimum number of actively-followed vehicles is two. Moreover, we show

that for low-density congestedtraffic the interaction range reaches relatively high values (four or five), which means that a driver (while driving) tracks four of five cars moving in front of her/him. Such a disclosure brings a new insight into a theory of vehicular dynamics.

Key words: vehicular traffic, statistical rigidity, headway modeling

---

Poverty mapping in small areas under a two-fold nested error regression model.

Domingo Morales

Universidad Miguel HernÃąndez de Elche, Spain

Email: d.morales@umh.es

Abstract

Poverty maps at local level might be misleading when based on direct (or area-specific) estimators obtained from a survey that does not cover adequately all the local areas of interest. In this case, small area estimation procedures based on assuming common models for all the areas typically provide much more reliable poverty estimates. These models include area effects to account for the unexplained between-area heterogeneity. When poverty figures are sought at two different aggregation levels, domains and subdomains, it is reasonable to assume a two-fold nested error model including random effects explaining the heterogeneity at the two levels of aggregation. The talk introduces the empirical best (EB) method for poverty mapping or, more generally, for estimation of additive parameters in small areas, under a two-fold model. Under this model, analytical expressions for the EB estimators of poverty incidences and gaps in domains or subdomains are given. For more complex additive parameters, a Monte Carlo algorithm is used to approximate the EB estimators. The obtained EB estimates of the totals for all the subdomains in a given domain add up to the EB estimate of the domain total. We develop a bootstrap estimator of the mean squared error (MSE) of EB estimators and study the effect on the MSE of a misspecification of the area effects. In simulations, we compare the estimators obtained under the two-fold model with those obtained under models with only domain effects or only subdomain effects, when all subdomains are sampled or when there are unsampled subdomains. The methodology is applied to poverty mapping in counties of the Spanish region of Valencia by gender. Results show great variation in the poverty incidence and gap across the counties from this region, with more counties affected by extreme poverty when restricting ourselves to women.

Key words: Empirical best estimator, Nested-error model, Poverty mapping, Unit level models, Small area estimation

Combining probabilistic expert opinions

Barbora Pálková

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: palkobar@fjfi.cvut.cz

Abstract

Let be assumed the existence of a group of sources, providing their opinions about underlying problem to each other and therefore acting within a cooperative scenario. These opinions can be expressed as probabilistic information. Proposed way to combine this discrete probability distribution is based on decision making theory and theroy of infromation. The optiomal combination is a probability mass function minimizing the conditional expected KL-divergence with respect to problem-reflectiong constraints.

Key words: distributed decision making, minimum cross-entropy principle

Likelihood tempering in dynamic model averaging

Jan Reichl

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: reicja9@seznam.cz

Abstract

We study the problem of online prediction with a set of candidate models using dynamic model averaging procedures. The standard assumptions of model averaging state, that the set of admissible models contains the true one(s), and that these models are continuously updated by valid data. However, both these assumptions are often violated in practice. The models used for online tasks are often more or less misspecified and the data corrupted (which is, mathematically, a demonstration of the same problem). Both these factors negatively influence the Bayesian inference and the resulting predictions. We propose to suppress these issues by extending the Bayesian update by a sort of likelihood tempering, moderating the impact of observed data to inference. The method is compared to the generic dynamic model averaging and to an alternative problem formulation via sequential quasi-Bayesian mixture modeling.

Key words: Model averaging, model uncertainty, prediction, sequential estimation, tempered likelihood

Procedural modelling of plants in computer graphics

Světlana Smrčková

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: margaritsmrckova@seznam.cz

Abstract

This work deals with procedural modelling of plants in computer graphics. It consists of a designing algorithm that is generating models of plants by using deterministic and context free grammars. To representant a surface of models, an implicit description of surface is used. Output of the work is coarse structure of plant and folder of data, that can be displayed by suitable program. 3D model is obtained by a visualization of the data .

Key words: computer graphics, D0L-systems, grammar, procedural modelling, rewriting rules

Statistical detection of an interaction range in particle systems

Zuzana Szabová

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: szabov.zuzana@gmail.com

Abstract

Knowledge of an interaction range in particle systems, especially in vehicular traffic could significantly contribute to modelling of traffic flow. Therefore we aimed our interest at statistical detection of an interaction range in particle systems. At the very beginning we implement the so called Metropolis-Hastings algorithm in order to validate derived analytical and approximative prediction of headway distribution $p_\eta(r)$ with short-ranged and middle-ranged logarithmic potential. Combination of simulation methods, analytical predictions of headway distribution and correlation analysis led to several observations. We determined, that interaction range depends on both resistivity η and type of repulsive potential. Next we discuss generally-accepted premise (on a short range of traffic interactions), which does not correspond to traffic reality as will be demonstrated by means of correlation analysis. Such an observations bring a new insight into a theory of traffic dynamics.

Key words: headway distribution, interaction in vehicular traffic, correlation analysis

Quantitative analysis of probabilistic dependencies in a thermal balanced traffic gas

František Šeba

University of Hradec Králové, Czech Republic

Email: frantisek.seba@seznam.cz

Abstract

We exploit some fundamental properties of functional convolution to detect the range of interactions between particles in a one dimensional thermal-relaxed traffic gas. We investigate, how much the convolution of the probability distributions describing the inter-particle spacing probabilities diverges from the joint probability of these distributions, and interpret the perturbation as a probabilistic dependence of the random variables describing the inter-particle spacings. From the range of the perturbation, we derive the number of interacting particles - the interaction range.

Key words: traffic microstructure, interaction range, statistical dependency

Latest discoveries in HEP

Vladislav Šimák

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: simak@fnal.gov

Abstract

The history of discoveries of elementary particles and the standard model will be reviewed and existence of followers of Higgs boson will be discussed. How can we interpret these new particles in terms of Quantum Field Theory? Are we able to find graviton? What are new trends in High Energy Physics and what happens at the LHC and other HEP experiments?

Key words: High Energy Physics (HEP), standard model, elementary particles, Higgs boson, graviton

Lazy-learning fully probabilistic decision making

Jakub Štěch

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: Stech@seznam.cz

Abstract

Abstrakt: The seminar covers a lazy learning approach to fully probabilistic decision making when a decision maker (human or articial) uses incomplete knowledge of environment and faces high computational limitations. The resulting lazy fully probabilistic design selects a decision strategy that makes a probabilistic description of the closed decision loop close to a pre-specied closed-loop ideal description. Instead of classical learning an environment model followed by optimisation, the lazy FPD uses the currently observed data to end the past closed-loop similar to the actual ideal model. The optimal decision rule of the closest model is then used in the current step.

Key words: lazy learning, fully probabilistic design, decision making

Improving performance of heuristic optimization for problems involving stochastic objective function

Ondřej Ticháček

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: ondrejtichacek@gmail.com

Abstract

Heuristic optimization is a widely used approach employed in various classes of problems. Most heuristic algorithms can be defined to minimize an objective function representing a loss or cost. Recently, we have tried to use heuristics in a calibration of a computational model. In this case, the objective function represents the model quality and takes the to-be-optimized parameters as arguments. Contrary to other application of heuristics, the evaluation of the objective function is by orders of magnitude more computationally demanding than other parts of the optimization procedure. The evaluation time can even be the factor limiting the applicability of such optimization approaches. Standard heuristic algorithms for optimization do not consider that the objective function may be stochastic, which is, for example, precisely the case for the problem of stochastic computational models' calibration. We introduce a simple but efficient approach to dramatically improve the performance of most standard

heuristic algorithms by analyzing the underlying distribution of the objective function. This approach requires only a few assumptions about the distribution and can be used in a variety of problems, not just the example case of calibration of a computational model.

Key words: optimization, heuristic, stochastic objective function, calibration

---

Application of statistical hypothesis testing to datasets from the high energy physics experiments

Jakub Trusina

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: trusijak@fjfi.cvut.cz

Abstract

Homogeneity tests are used in high energy physics for verification of measured data having same distribution as Monte Carlo generated samples. Kolmogorov-Smirnov, χ^2, and Anderson-Darling tests are used to test the samples' homogeneity. Monte Carlo generators produce samples which entries have assigned weights. To test for homogeneity of data and Monte Carlo sample, generalized (weighted) tests are needed. However, suggested test statistics' asymptotic properties are not proven; therefore, they are inspected in numerical analysis which focuses on estimations of type-I error and power of test. Homogeneity tests are afterwards used to determine homogeneity of measured data from ATLAS experiment and Monte Carlo samples.

Key words: weighted samples, numerical analysis of homogeneity tests, Anderson-Darling test, Kolmogorov-Smirnov test, chi-squared test, ATLAS experiment

---

Perturbation theory for statistical rigidity in particle systems

Jana Vacková

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: vackoja4@fjfi.cvut.cz

Abstract

We begin by defining two sets of random variables for a one-dimensional particle system - one of them being headway between the reference vehicle and other vehicles and the other variable is interval frequency. We explore their mutual relations and present an important characteristic of these systems,

statistical rigidity, along with its Laplace image. Afterwards, the system in question is axiomatically defined to correspond with real traffic systems. Then we explore the asymptotic behaviour of statistical rigidity for both short-range and middle-range systems. Furthermore, we find analytical predictions of compressibility for these systems. We numerically verify all of these analytic formulas. In the summary, localization of traffic system in the fundamental diagram is discussed.

Key words: Headway, interval frequency, statistical rigidity, interaction range, compressibility.

MC samples generation & ATLAS distributed computing

Petr Vokáč

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: vokac@fjfi.cvut.cz

Abstract

...

Key words: HEP, MC, ATLAS, ADCOS

Iterative methods in compressed sensing

Hynek Walner

Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic

Email: hynekw@gmail.com

Abstract

Many data reconstruction problems can be successfully written in a constraint optimization manner. We will show such formulation on medical data as a problem of finding optimal trade-off between closeness to input data and improvement prescribed by regularization function. Furthermore, iterative solution based on evaluation of so-called proximal operator will be presented and finally alongside with reconstructed data acquired by nuclear magnetic resonance scanner stationed at Czech Institute of Scientific Instruments.

Key words: compressed sensing, perfusion NMR, iterative data reconstruction, proximal methods

---

Layered simulation model of ultrasound wave propagation along skin tissue

Jana Zatloukalová[1,2], Daniel Tokar[2], Zdeněk Převorovský[2]

[1] Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Prague, Czech Republic
[2] Institute of Thermomechanics, Academy of Science, Prague, Czech republic

Email: zatlo.ja@gmail.com

Abstract

Elasticity of the skin reflects aging and diseases. It may be an important parameter in medicine and cosmetics. Unique ultrasonic measurement device enables local skin evaluation in axial direction parallel with the the skin surface. Parameters of non-linear elasticity can be derived from ultrasonic signals propagating along the skin tissue. Based on non-linear Burger's equation we simulated wave propagation in axial transmission along the layered model of the skin. Due to non-linearity of the propagated medium, higher harmonics are generated in numerical simulations and observed in experiments as well. Nonlinear characteristics are evaluated from the ratio of third and second harmonics. Influences of the model parameters on coefficient of non-linearity are investigated in this contribution, e.g. of the wave celerity, medium density and diffusivity, etc. The contribution of various skin layers is discussed, and, finally, numerical and experimental results are compared.

Key words: Numerical simulation, skin elasticity, nonlinearity

Notes