SPMS 2013

Stochastic and Physical Monitoring Systems

Book of abstracts of the international conference

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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

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Foreword

Dear Colleagues,
it is our pleasure to welcome you to the 4^{th} STOCHASTIC & PHYSICAL MONITORING SYSTEMS.

The SPMS 2013 conference is held for the fourth 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 hotel Hladina in Nebřich on the bank of the Slapy dam.

Local Organizing Committee:

Jiří Franc, Tomáš Hobza, Pavel Hrabák, Václav Kůs (Chair)

Scientific and Program Committee:

Václav Kůs, Tomáš Hobza, Milan Krbálek

Invited Speakers:

František Hakl, ICS - Czech Academy of Sciences, Prague, Czech Republic
Milan Chlada, IT - Czech Academy of Sciences, Prague, Czech Republic
Domingo Morales, Universidad Miguel Hernández de Elche, Spain
Leandro Pardo, Universidad Carlos Terceros, Madrid, Spain
Zdeněk Převorovský, IT - Czech Academy of Sciences, Prague, Czech Republic
Serge Dos Santos, ENIVL Blois & Univ. F. Rabelaise Tours, France
Petr Vokáč, DØ experiment, Fermilab, Batavia, USA

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The Organizers

Contents

An algorithm for generating correlated random variables

Petr Bohuslav

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Abstract

Simulations are often needed when the performance of new methods is evaluated. Many algorithms have been developed to generate independent random variables but there are only several algorithms that are capable of generating correlated random variables. An algorithm for generating non-Gaussian random variables with a special correlation structure will be described and the results of the tests that analysed the algorithms output quality will be presented. Additionally, a comparison of this algorithm and an algorithm for generating spike trains will be drawn.

Key words: Random variables, correlation, non-Gaussian distribution.

Pedestrians' movement: experimental approach to egress studies

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Abstract

The domain of pedestrian dynamics studies suffers from the lack of experimental data, which are very important both for primary research and also for calibration and verification of the models. To realize a reliable experiment, the "normal" conditions must be kept, otherwise the participants behave differently than in the ordinary situations. Simultaneously, the design must be simple enough, the motivation of participants and other parameters influencing the decision process must be easy to assess. To track a motion of one person, it is necessary to monitor both, velocity and directions, therefore video records are frequently used. The data from cameras are difficult to process – the snapshots are garbled by angle of view and other phenomena. This contribution deals with all tasks described above, it illustrates the process of planning, monitoring and evaluating the experiments. The concept of microscopic and macroscopic approach is presented and the basic quantities describing pedestrian movement – pedestrian's density and flow – are defined. With respect to the goals of given experiment,

different methods of extraction these quantities from records are used. At the end, the analysis of velocity – density dependence, occupancy and the time headways of leaving pedestrians is provided.

Key words: Pedestrian dynamics, egress experiment, image recognition.

Monitoring and vulnaribility of complex multiscale systems using stochastic data processing

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Abstract

Nonclassical nonlinearity is now recognized to be a keystone of aging and degradation processes of mesoscopic materials. Monitoring the vulnaribility of these miltiscale systems is the keystone for understanding properties of the time evolution of such complex systems. Thanks to the use of new multimodal ultrasonic imaging methods, this new class of multiscale materials can be studied with so-called phenomenological approaches like the Preisach-Mayergoyz space (PM space). Some physical properties like hysteresis, end-point memory, and odd harmonic generations are now extracted from the noise using specific nonlinear signal processing. Among them, Time Reversal (TR) based Nonlinear Elastic Wave Spectroscopy (NEWS) systemic methods have the potential to become a powerful and promising tool for the Non Destructive Testing (NDT) industry, but also for new forms of secure communication [1]. They provide the wish to detect and image structural damage in complex medium, thanks to the use of advanced signal processing techniques based on multiscale analysis. The systemic approach of the TR-NEWS ultrasonic complexity is presented with extended experimental results developed for echodentography applications on human tooth. The multi-modality of this imaging approach associated to the complexification of focusing performed with phononic cavities is presented as an example of an emerging innovation in the field of nonlinear ultrasonic imaging. Finally, a discussion is proposed for applying phenomenological approaches for organizations strategies using these multiscale tools used for analyzing non-classical nonlinear damaged mesoscopic materials.

[1] Nonlinear Time Reversal in a Wave Chaotic System, Matthew Frazier, Biniyam Taddese Thomas Antonsen and Steven M. Anlage, Phys. Rev. Lett., 110, 063902 (2013)

Key words: Non Destructive Testing, ultrasonic imaging, nonlinear signal processing, TR-NEWS, multiscale systems, stochasticity, monitoring of complex systems.

MVA methods for the single top cross section measurement

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Abstract

The observation of the electroweak production of single top quarks in the $D\emptyset$ detector at the Fermilab Tevatron $p\bar{p}$ collider is introduced and different MVA methods used in the separation of the signal from the background are presented. The selection of input variables, transformations and tuning of some separation techniques are discussed. Finally, the sensitivity of each analysis and quality of separation is evaluated and the separation results from all methods are showed and compared.

Key words: Multivariable analysis, classification, single top quarks, cross section.

Neural network with switching units and its application in HEP

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Abstract

We introduce a separation algorithm of a neural network with switching units (NNSU) and present its applicability to data mining applications. NNSU algorithm exploits principles of artificial multilayer perceptron like neural networks and linear decision trees. Combination of both approaches provides more flexible tools for set separation.
The training phase of NNSU uses a genetic optimization of NNSU architecture, which is in general an acyclic oriented graph, hence a convenient definition of corresponding genetic fitness function allow us to tune separation results to meet user defined requirements.
We tested usability of NNSU model in different problems in high energy physics data processing, among others Higgs boson search.
In the next we discuss shortly the possibility of efficient hardware implementation. Owning to the fact that response phase of NNSU algorithm behaves as a piecewise linear discriminant the testing phase of the algorithm can be performed by hardware means only. First step toward hardware implementation was done, and possibility of full electronic implementation was studied. On the base of this study we

estimate that event processing speed about 25 mega-samples per second is reachable by full hardware implementation without significant degradation of separation quality.

Key words: Neural network, switching units, separation, genetic optimization, high energy physics.

Statistical learning theory

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Abstract

A probabilistics learning theory known as PAC-learning attempts to clarify relationships between a number of learning patterns, geometrical (or/and algebraical) properties of hypothesis directory and the quality of produced hypothesis which estimates objective (targeted) learning set. The main goal of the lecture is to present whole framework of PAC learning model, introduce basic notions connected with the theory presented such as VC-dimension, pattern complexity, uniform lernability, and refutability of learning algorithms. The main theoretical result presented is upper bound of patterns set size regard to predefined (ϵ, δ) precission of resulting hypothesis. As a direct consequence of this result we mention the fact that almost all "reasonable" learning algorithms are uniformly learnable. Finally some notes we pay to more applicable extension of clasicc PAC model, so called refutable learning model.

Key words: Probabilistic approximatelly correct, Vapnik-Chervonenkis dimension, uniform lernability, pattern complexity, membership queries learning, refutable learning.

Robustness of MDE under adaptive nonparametric density estimates

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Abstract

Minimum distance estimators are considered with respect to relative efficiency and robustness. Nonparametric density estimates such as histogram and kernel density estimates are presented. Stochastically equivalent histogram density estimate is introduced and implemented. The influence of various modifications of these nonparametric density estimates on the robustness of MDE is shown. The robustness

of Power divergence estimates under the histogram, stochastically equivalent histogram and kernel density estimates is examined in a simulation study. Results are compared with Renyi estimates which, by definition, do not require density estimates in their evaluations.

Key words: Minimum distance estimators, kernel density estimates, histogram, robustness.

Time-headways for interacting particle systems in stationary state

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Abstract

General approach of analytical derivation of time-headway distribution for interacting particle systems based on car oriented mean-field approximation (COMF) is presented. Crucial problems are discussed and demonstrated by simple models as TASEP or ZRP. Several updating procedures are discussed in the scope of above mentioned method using both, analytical and numerical results.

Key words: Time-headway, particle system, TASEP, COMF.

Parametrization of time-reversed signals

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Abstract

Human skin is a complex biomaterial with specific mechanical properties, e.g. nonlinear stress-strain behavior, viscoelasticity, and anisotropy. Knowledge in mechanical properties of the skin is of great interest in dermatology, plastic surgery and also in rehabilitation, and cosmetics. In this paper an investigation of anisotropic behavior of the back and knee skin tissue is presented. Anisotropy characteristics are determined by ultrasonic wave propagation velocity and attenuation changes. A special multi-directional flexible ultrasonic probe enables local investigation of skin anisotropy in vivo. Results obtained from local measurements are used to create an anisotropy map of the back and knee skin tissue. Human skin anisotropy mapping brings an easy method to evaluate the anisotropy of specific skin tissue and

to better understand the complex mechanical behavior of the skin. Presented approach also helps to understand the ultrasonic wave propagation in the skin with respect to the direction of propagation.

Key words: Anisotropy, human skin, in-vivo, viscoelasticity.

Multilevel analysis of continuous acoustic emission records

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Abstract

The latest acoustic emission (AE) systems provide continuous recording of high-frequency signals registered during longtime monitoring of various processes in materials. Recorded data represent extremely large amount of information to analyze, however, it reflects the health of the structure. Therefore, in the last years the attention is paid to the diagnostic method of continuous AE also as a part of Structural Health Monitoring (SHM) systems. For example it can disclose the early damage phases (cracks) or certain imperfections in rotating gearboxes, the leakage of liquids from pressure vessels and many other material defects. This method requires new signal processing and analysis approaches, which are different from the burst AE. The paper deals with the analysis of continuous AE, recorded during the test of renovated gearbox at different flight modes. As an alternative to classical spectrogram, the histogram of time periods between each amplitude threshold crossings (so-called multilevel countogram) based on the signal wavelet decomposition is proposed and discussed. Monitoring of the continuous AE together with vibration analysis should be integral part of helicopter in-flight SHM systems in near future.

Key words: Continuous acoustic emission, wavelet analysis, countogram, helicopter gearbox diagnostics.

Design of mathematical model and analysis of insurance loss data

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Abstract

Water may cause large environmental and social disasters. Therefore, there are attempts to control and predict both behavior and consequential losses of this element. This work is focused on prediction

of inundation losses in residential areas. Such a prediction can be useful besides other things in an insurance branch. Data has been provided by Aon Benfield, risk theory manager and hedging broker. In this work, data control and cleaning procedures are presented. After that, different forms of linear models and various transformations are tried and subsequently an influence of corresponding parameters is studied. Eventually, the Generalized linear model is presented and its intermediate results explaining behavior of the inundation losses are discussed.

Key words: Inundation, insurance, data analysis, linear models, generalized linear models (GLM).

Median estimate in logistic regression model

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Abstract

Nowadays, generalized linear models are widespread for statistical data processing. Logistic regression model belongs to this class of models. This model is one of the basic models used for binary data. A demand for accurate and reliable estimates of the parameters of these models is increasing. MLE (Maximum Likelihood Estimates) are used in practice. They are known to be efficient. Unfortunately, the outliers can occur in some data sets, which have an effect on estimation of model parameters. Median estimate of parameters and its generalization are proposed for these data sets. In this work, MLE, Median estimate and generalized Median estimate are compared on generated data. As a conclusion, a comparison between them is shown.

Key words: Generalized linear models, logistic regression model, median estimate.

Matrix reloaded II

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Abstract

As well known, the microstructure of many theoretical or empirical systems corresponds (in a certain sense) to the configuration of eigenvalues generated by the Random Matrix Ensembles (like GUE,

GOE, GSE, BRME). Especially, there exists a great set of physical/economy/social systems whose inter-particle gaps (here denoted by variable s) are distributed according to the formula

$$wp(s) = A\Theta(s)s^{\eta}\mathrm{e}^{-Bs}, \quad A = A(\eta), B = B(\eta). \qquad (1)$$

Surprisingly, inter-vehicle headways of vehicular systems do not correspond to the probability density (1). Instead, the detected gap distribution is of a form

$$wp(s) = A\Theta(s)\mathrm{e}^{-\frac{\eta}{s}-Bs}, \quad A = A(\eta), B = B(\eta). \qquad (2)$$

Long-lasting endeavour of contemporary mathematics is to discover new type of random matrices such that the associated level spacing is described by the function (2). We will demonstrate a possible way how to attain it.

Key words: Random matrix theory, mathematical modeling of traffic flows, level spacing.

Rényi decomposable minimum distance estimators and signal separation through divergence decision trees

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Abstract

Rényi information divergences are well-known and widely used in statistical inference due to their robustness and practical feasibility. M-C simulation results for the Minimum Rnyi Distance (MReD) estimates in the case of small sample data sets are presented and the effect of input parameter $alpha$ to robustness is shown. Heuristic approach is proposed for such MReD estimates when the strict minimization leads to delta functions. Divergence based decision trees (PhiDT) are presented as well as some attempts of the implementation of teacher (supervised learning) to this originally unsupervised classification method. Subsequent PhiDT signal sepa rations were carried out for the Single Top Quark decay channel, i.e. the data samples coming from high energy particle accelerator Tevatron in Fermilab obtained at the energy level 1.96TeV and the beam luminosity $9.5fb^{-1}$.

Key words: Minimum distance estimators, robustness, decision trees, $/phi-$divergences.

Kolmogorov–Cram'er estimator: theory & simulation & application

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Abstract

We deal with minimum distance estimators for newly modified Cram'er–von Mises distance. The generalized power form of Cram'er–von Mises distance is defined together with the so called Kolmogorov–Cram'er distance which includes both standard Kolmogorov and Cram'er–von Mises distances as limiting special cases. The consistency of such Kolmogorov-Cram'er estimator in the L_1–norm was proven recently (2012-2013). Thus, through numerical simulation, we illustrate the quality of consistency for sample sizes from $n = 10$ to $n = 500$ and for various ε-contamination neighborhood of the true model. Further, the robustness of these new estimators is carried out. Numerical simulations are used to compare statistical properties of the minimum Kolmogorov–Cram'er, generalized Cram'er–von Mises, standard Kolmogorov, and Cram'er–von Mises distance estimators of the normal family scale parameter. We deal with the corresponding order of consistency and robustness, the resulting graphs are presented and discussed for the cases of the contaminated and uncontaminated pseudo-random samples.

Key words: Distance measures, robustness, consistency, simulations.

Advanced algorithms for change point signal detection resulting in AE source localization

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Abstract

The target of this contribution is to bring a representative overview of algorithms used for change point detection in physical dynamical systems and to compare the precision of AE source localization using these algorithms. We focus on showing possible improvements of the consequent AE source localization.

Also the comparison of implemented algorithms with respect to the basic threshold overshoot algorithm is provided. Algorithms used can be divided in two groups, the parametric and non-parametric algorithms. To the parametric class, the likelihood ratio based algorithms belong, e.g. Geometric Moving Averages (GMA) and Cumulative SUM (CUSUM) algorithm. Further, the algorithm using Schwarz Information Criteria (SIC) and the algorithms based on parameter estimates of auto-regression sequences (AR) with consecutive χ^2-test are explored. The group of non-parametric algorithms contains the non-parametric version of CUSUM algorithm, the non-parametric algorithm inspired by SIC and the Singular Spectral Analysis (SSA) change point detection. To show the possible improvements of AE source localization, we test these algorithms on data sets from experiment on a thin metal plate, where we detect the pentest AE source.

Key words: Signal processing, change point detection, signal source localization.

Condensation in Zero-Range Processes

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Abstract

This paper briefly summarizes available information of zero-range processes. Brief summary on Markov semi-group is given to develop satisfactory tools for building Markov process on infinite state space. Due to known Markov core of such given Markov process, we are able to develop appropriate system by giving jump rates and jump probabilities for asymmetric system. Defining condensation phenomenon in probability sense we are able to describe phase transitions and find out stationary measure. Finally we will give some insight to describe dynamics of condensation.

Key words: Condensation, zero-range process, stationarity.

Small area estimation of labour force indicators under a multinomial mixed model with correlated time and area effects

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Abstract

The aim of this work is the estimation of small area labour force indicators like totals of employed and unemployed people and unemployment rates. Small area estimators of these quantities are derived from four multinomial logit mixed models, including a model with correlated time and area random effects. Mean squared errors are used to measure the accuracy of the proposed estimators and they are estimated by analytic and bootstrap methods. The introduced methodology is applied to real data from the Spanish Labour Force Survey of Galicia.

Key words: Small area estimation, Generalized linear mixed models, unemployment rates.

Viscoelastic and non-linear properties of human skin

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Abstract

Human skin is a complex stratified biomaterial with specific mechanical behavior. The contribution is focused on its viscoelastic properties because they are not well determined. These properties are of great interest in medicine, plastic surgery and cosmetics.
A special skin-loading device is used for study of viscoelastic behavior. The device consists of two combined parts. The first one is a mechanical part allowing stepwise tensile loading of the skin. The other part is an ultrasonic measurements equipment. Signal processing techniques enable examination of the skin behavior in various stress states. Behavior of the skin under loading depends on the age, sex, and place on the tested person and also on temperature and humidity of the environment.
To determine the non-linear properties of the skin we used a pulse inversion method, which can detect nonlinearity. This approach consists in transmitting a pulse signal and its time-reversed counterpart into the loaded skin, and the two signals received along its their propagation path are added. Some non-linear properties are characterized by addition result.

Results obtained using these methods can help us to understand the mechanical behavior of the human skin, its viscoelastic properties and their instantaneous changes under different conditions.

Key words: Skin, signal processing, viscoelasticity, nonlinear properties.

Robustness and Density Power Divergence Measures: Estimation and Testing

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Abstract

In any parametric inference problem, the robustness of the procedure is a real concern. A procedure which retains a high degree of efficiency under the model and simultaneously provides stable inference under data contamination is preferable in any practical situation over another procedure which achieves its efficiency at the cost of robustness or vice versa. The density power divergence family of Basu et al. (1998) provides a flexible class of divergences where the adjustment between efficiency and robustness is controlled by a single parameter β. In this talk we consider these divergences to construct a robust class of hypothesis tests with good efficiency for simple null hypothesis as well as for composite null hypothesis.

Key words: Robustness, divergence measures, hypothesis testing.

Time reversal procedure used to acoustic emission signal deconvolution

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Abstract

Propagation of elastic waves excited in a complex body is a complicated process due to wave interactions with the body boundaries, structure irregularities, and other obstacles causing wave mode conversion, attenuation, and dispersion effects. Wave dispersion, i.e. frequency dependence of phase or group wave

propagation velocity is observed when the wavelength becomes comparable with the body dimensions. Dispersion can be caused as by the sample geometry as by material itself (geometrical and material dispersion, respectively). All these wave propagation effects lead often to substantial loss of information about the wave source origin.
One of the important nondestructive testing methods connected with elastic wave propagation from an unknown source to sensors placed on a body surface is acoustic emission (AE) monitoring. AE source location and identification in the complex body represent extremely difficult inverse problem solution, solvable in many real situations neither analytically nor numerically. AE signals, detected relatively far from the AE source are generally considered as a result of multiple convolution of the AE source function with the elastic wave transfer (Green's) function, and with a transfer function of sensors connected with following signal processing devices. We suggested new concept of precise AE source localization and identification in complex structures. New method is based on a Time Reversal (TR) AE signal processing. To obtain the source signals not affected by the wave propagation from the source to sensors, AE signals detected by more receivers are time reversed and rebroadcast using the same piezoelectric transducers switched into the transmitting mode. Roughly localized AE source area is scanned with contact or non-contact sensor (e.g. laser interferometer) and perfect synchronization of detected TR signals points out the precise source location. After deconvolution concerning transducer and device transfer functions, the TR signal represents partially reconstructed AE source function, which is then used to its identification. Suggested offline procedure, called TRAED (TR AE signal Deconvolution) is relatively simple and doesn't require any knowledge about the structure material and geometry [1]. Its use, merits, and limits are demonstrated on examples of artificial AE sources (PEN-Tests, defined ultrasonic pulses) acting on steel and composite plates, and also on complex parts of an aircraft. Results show effectiveness of both inverse problems solution dealing with precise source location and partial reconstruction of the source function. TRAED also removes effects of anisotropy and wave dispersion, and minimizes scatter of parameters derived from AE signals detected by differently spaced transducers. The method can be also applied to the well-designed computer simulation model of elastic wave propagation in the structure without any additional experiments.

[1] Z. Prevorovsky, J. Krofta, M. Chlada, Z. Farov, V. Kus: Progressive Approaches to Localization and Identification of AE Sources. Keynote, '30 EWGAE / 7 ICAE', Granada, Spain, 12-15 Sept. 2012, CD Proc. ISBN13: 978-84-615-9941-7, http://www.ndt.net/EWGAE-ICAE2012

Key words: Time reversal signal processing, acoustic emission, source location, signal deconvolution.

Sensitivity and robustness of signal separation techniques under new set of spectral and energy attributes

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Abstract

The acoustic emission (AE) defectoscopy principle, based on the acoustic signals generated by materials under load, is used to characterize and identify the damage developments. Reliable identification and

classification of pre-localized AE sources is one of the most important and also most difficult problems in AE monitoring. We measured acoustic emission signals by means of Xedo-5 measuring device with the piezo-ceramic sensors. Subsequently we deal with the classification of acoustic emission random signals through statistical clustering such as the Fuzzy Clustering Method (FCM) and the Gaussian Mixture Model (GMM). The signals are separated by means of attributes obtained directly from the signals or from signal spectrums, e.g. the maximum module of the FFT transformation or the energy of signal. We carry out acoustic emission experiment to test the proposed classification attributes and further we perform a computer simulation study in order to find out the robustness and sensitivity of the corresponding signal classification techniques which can be applied to any other physical separation tasks such as occurrence and propagation of cracks in a nuclear reactor or accelerated particle physics signals.

Key words: Classification, acoustic emission.

Separation based on Divergence Decision Trees for AE and Fermilab Single Top Quark data sets

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Abstract

Classification of data into clusters is very broad branch of data processing. There exist many classification methods, both supervised and non-supervised. This work deals with a new classification method Divergence Decision Tree (DDT), which links together basic classification based on k-means method and phi-divergence measure as a decision criterion. Different phi-divergence generating functions are considered and the separation results are compared in order to find out the dependency of the method on selected divergences. It was traced that the K-means separations as a basic part of the DDT algorithm, used in each tree node, have several disadvantages. Therefore, the fuzzy classification method was incorporated as a component of the DDT method. Several versions of DDT separation for various phi-divergences under basic fuzzy clustering are tested on data sets originated from the acoustic emission experiment or from Fermilab Single Top Quark production channel. The results are compared with results of fuzzy method as self-contained method.

Key words: Clustering, decision tree, phi-divergence, fuzzy classification.

Sensitivity and robustness of signal separation techniques under new set of spectral and energy attributes

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Abstract

Diagnosis of Alzheimer's disease is complex and actual problem. Human brain activity can be investigated by several methods. The subject of our interest is Single Photon Emission Computed Tomography (SPECT) which generates 3D image of ^{19}F-deoxyglucose concentration. Resulting image can be treated as density map of three-dimensional stochastic variable. Various statistical measures as distances, divergences, entropies, and mutual information are applied to construct indicators of Alzheimer's disease. These indicators are exposed to statistical testing for deciding about their diagnostic power. In addition to hypothesis testing, the results are presented in the form of Receiver Operating Characteristics (ROC) curves and Wishart diagrams, as well.

Key words: Statistical measures, Alzheimer's disease

Two-dimensional variant of model TASEP and study of the microstructure of small lattice

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Abstract

The totally asymmetric simple exclusion process (TASEP) is a mathematical model used for traffic modelling. It belongs to group of models using microscopical approach. TASEP is defined as a stochastic process taking place on a discrete one-dimensional lattice of extitN sites. We will present a two-dimensional generalization of this model acting on two-dimensional square lattice. Update rule is defined as follows: a particle jumps with probability extitp if the upper site or right site is empty. Moreover, the lattice has open boundary, where a particle can be inserted or taken out of the system. The simulations of this model will be introduced. As the model is stochastic system, the change of the probability of configurations is defined by the solution of the master equation. This system is described

by transfer matrix $\mathcal{H}$ called Hamiltonian. We construct this matrix for small lattices and also we will focus on model properties, such as probability of configurations and so on.

Key words: TASEP, Hamiltonian, master equation.

On the class of balanced distributions

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Abstract

A new class $\mathscr{B}$ of balanced distributions is introduced. After formulating the definition, basic properties of the class $\mathscr{B}$ are derived and the concept of a balanced-distribution kernel is proposed due to its significant importance throughout the theory. The main benefit of the balanced-distribution kernel and its properties is simplification of the work with the class $\mathscr{B}$. Also, the relationships between balanced distributions and long-tailed or heavy-tailed distributions as well as between balanced distributions and Laplace space $\mathscr{P}$, Schwarz-Laplace space $\mathscr{S}_+$ or the class of generalized functions with positive support $\mathscr{D}_+$ are discussed. At the end the application of this theory in traffic systems is outlined.

Key words: Balanced distributions, balanced-distribution kernel, traffic systems.

Separation of the single top quark by Model based clustering

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Abstract

The DØ experiment was one of two large particle physics experiments at Fermilab which was marginally focused on the research of the single top quark. First, the physical background of this experiment will be briefly described, and then the theory of distribution mixtures as a method for separating the single top quark will be presented. The quality of separation is highly dependent on computational aspects of the EM algorithm such as choice of initial conditions and optimal numbers of components. There are also ways how to make this algorithm stable. Moreover, the application of EM algorithm to weighted Monte Carlo data and the use of Bayesian statistics will be demonstrated. Finally, the present results will be discussed together with other possibilities for improvement.

Key words: Model based clustering, distribution mixtures, EM algorithm, single top quark

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Data processing for results of time reversal acoustics

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Abstract

Time reversal acoustics (TRA) is a promising tool that is used for non-destructive testing of materials. Its great advance is in sensitivity for third order nonlinear behavior that is crucial in assessment of material quality. Evaluation of third order nonlinearity coefficient can be done by ESAM (Excitation Symmetry Analysis Method). This method is generalization of well-known pulse inversion technique. I will discuss disadvantages of ESAM and then I will describe techniques that could be used for enhancement of this method. And at the end of my speech, I would like to talk about possible ways of visualization of results obtained by TRA.

Key words: Time reversal acoustic, excitation symmetry analysis method.

Human skin anisotropy mapping in vivo using multi-directional ultrasonic probe

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Abstract

Human skin is a complex biomaterial with specific mechanical properties, e.g. nonlinear stress-strain behavior, viscoelasticity, and anisotropy. Knowledge in mechanical properties of the skin is of great interest in dermatology, plastic surgery and also in rehabilitation, and cosmetics. In this paper an investigation of anisotropic behavior of the back and knee skin tissue is presented. Anisotropy characteristics are determined by ultrasonic wave propagation velocity and attenuation changes. A special multi-directional flexible ultrasonic probe enables local investigation of skin anisotropy in vivo. Results obtained from local measurements are used to create an anisotropy map of the back and knee skin tissue. Human skin anisotropy mapping brings an easy method to evaluate the anisotropy of specific skin tissue and to better understand the complex mechanical behavior of the skin. Presented approach also helps to understand the ultrasonic wave propagation in the skin with respect to the direction of propagation.

Key words: Anisotropy, human skin, in-vivo, viscoelasticity.

Neural networks in high energy physics analysis

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Abstract

Big particle accelerators like Tevatron in Fermilab or LHC in CERN generates an enormous amount of data. The most of the data originate from background. So there is a need to process collected data and separate this data to two sets. The one set contains events originated from background and the other set is made of purified data that originate from collision in the accelerator. To handle this uneasy task and due to the complexity of data, we prefer to use methods with training. The most popular methods are BDT (Boosted Decision Threes), SVM (Support Vector Machine) and NN (Neural Networks). Now, there are in use three different multilayer percepton implementations of NN. We developed a new approach how to classify data from accelerators via NN. So we are trying to break through with the fourth implementation and we will show achieved results of this freshly developed method compared with results what we have got by use of already existing implementations of NN and BDT.

Key words: Neural networks, high energy physics, pattern recognition.

Stochastic modelling in view of black swans

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Abstract

The talk will be based on a groundbreaking book by N.Taleb - Black Swan. The central theme will the concept of so called black swan and its implications to construction and usage of stochastic models including prediction of random phenomena. A fundamental difference between ""gaussian world"" and situations with heavy tailed distributions will be mentioned. In the end some philosophical aspects will be discussed.

Key words: Stochastic models, verification of assumptions, heavy tails, black swan.

Getting physics results from DZero experiment

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Abstract

Introduction to the experimental high energy physics (HEP) that can be done using particle accelerators and multipurpose detectors. We will discus basics of the experimental setup for DZero detector at the Tevatron proton anti-proton collider in Fermilab USA. We will use ttbar cross section analysis to demonstrate steps that are necessary to get final physics result from raw data recorded by DZero detector for decay products of collided particles. We will try to emphasize places where statistical methods have huge impact on precision of the final physics result.

Key words: Experimental high energy physics, Tevatron, DZero detector, ttbar cross section analysis.

Stochastic differential equations with jumps

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Abstract

It is well known, that stochastic differential equations (i.e. differential equations which solutions are stochastic processes) can be used to successfully describe random fluctuations in various physical, economical and social systems, such as thermal fluctuations, stock prices or biological modeling. We will demonstrate how to obtain exact solution of nonlinear equation describing cancer tumor growth under influence of drugs with continuous fluctuations, represented by Wiener process and then, we will generalize this model with additive discontinuous noise, represented by martingale originated from Poisson process. Also, we will derive exact solution to this generalized model using key tools from Ito calculus.

Key words: Martingales with jumps, Ito calculus, exact solutions of stochastic differential equations.

Geodetic iterative localization and statistical cluster separation in acoustic emission

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Abstract

The thesis deals with the AE source localization based on precise computations of geodesics on a given surfaces. Newton-Raphson procedure is implemented for the geodesic equations computation purpose. On this basis, new efficient variants of localization algorithms employing Direct Search Methods (Compass algorithm, Reduced Newton method and Nelder-Mead method) for minimizing distinctions between the real measured time differences and the computed length differences found via geodesics is developed. Having obtained the localization maps, the single AE sources are clustered by means of Model-Based separation EM algorithm adapted to curved surfaces. The demonstrative examples are given for the case of spherical propane-butane storage tank localization map. The aggregated procedure is applied to our own experiment on the Galvanized Steel Watering Can that represents a vessel with higher geometrical complexity.

Key words: AE source localization, geodesics, Nelder-Mead method, Model-Based clustering