SPMS 2012

Stochastic and Physical Monitoring Systems

Book of abstracts of the international conference

June 25 - June 30, 2012, Zlenice, 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 SGS project SVK 16/12/F4

Foreword

Dear Colleagues,
it is our pleasure to welcome you to the 3^{rd} STOCHASTIC & PHYSICAL MONITORING SYSTEMS.

The SPMS 2012 conference is held for the third 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, and Small area estimation of geographical characteristics gained from data sets, which are briefly called stochastic and physical monitoring systems.

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 Sázavka resort in Zlenice on the bank of the Sázava River. What started in Děčín in 2010 and continued in Křižánky in 2011 has grown to full international conference with over 35 participants with oral presentations and a number of invited speakers. The SPMS conference links both the informal character of lively student meeting and the unique platform for the research presentations and discussions of the conference participants.

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Jiří Franc
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Domingo Morales, UMH de Elche, Spain
Zdeněk Převorovský, IT - Czech Academy of Sciences, Prague, Czech Republic
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We gratefully acknowledge the institutional support provided by the funds of specific research, namely by the SGS grant SVK 16/12/F4.

The Organizers

Contents

Geodesic Iterative Methods for Nonlinear Acoustic Sources Localization: Application to Cracks Detected with Acoustic Emission

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Abstract

The presentation is related to Acoustic Emission (AE) principle, which is a Non-destructive Testing method (NDT) for structural health monitoring. The acoustic measuring devices Xedo-5 and IPL-3 recording the synchronous continuous 4chanels AE signals can be used for acoustic source localization on the surface of solid body, which is mathematically described as a conjunction of several simpler shapes of parameterized surfaces like cylinders, spheres, cones,... with intersections between them. We demonstrate a numerical solution of geodesic equations by the algorithm Iteration functional. The whole algorithm for finding geodesics on combined surfaces is applied to virtual testing body which is a wing component of a plane.

Key words: Acoustic Emission, Non Destructive Testing (NDT), acoustic source localization, geodesic equations.

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A cellular model of pedestrian movement and the leave-the-room experiment

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Abstract

The cellular automata models constitute a strong tool to simulate a pedestrian movement. This work briefly presents a CA model based on motion of autonomous agents. Their decision process contains movement and occupancy prediction, the information about geometry is included in potential field. The movement is discretized to rectangular lattice, the time is simulated by realistic timeline. To explore the pedestrian motion, the leave-the-room experiment was organized. With respect to the macroscopic observations, a generalized potential is proposed, which describes the "light bulb" shape of crowd in exit area better then common spherical potential. Also the time intervals of leaving people were examined, the dependence on waiting time was uncovered.

Key words: pedestrian dynamics; cellular automata model; evacuation experiment.

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Numerical simulation of the Dyson's gas

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Abstract

In traffic studies, Dyson's Coulomb gas can be used as a good traffic flow simulator. Dyson's gas is a thermodynamic gas consisting of particles moving on the unit circle and interacting with each other. Forward movement depends not only on the type of potential, which acts on the particles, but also on the number of particles interacting with each other.
Since this is an energy-conserving physical system, it can be described in Hamiltonian formalism. First, the Hamiltonian is the total energy of the system. The gas, with some certain thermodynamic temperature, is trying to achieve minimum of its energy. On this principle the Metropolis algorithm is based. It is the Monte Carlo simulation of the Dyson's gas. Second, the equations of motion can be derived from Hamiltonian. For integrating Newton's equations of motion we use the Verlet method and the adaptive Verlet method, based on the rescaling of time steps.

Key words: Dyson's gas; Verlet; Metropolis algorithm.

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Stochastics in Nonlinear Signal Processing : from mesoscopic materials to social monitoring

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Abstract

Accurate analysis of nonlinear systems needs the use of new methods of signal processing. Most of systems used in engineering presents a level of nonlinearity that was considered negligible and included in the small stochastic part of the noise. Modern engineering is developed now by considering this stochastic part of the nonlinear signature as a new vector of information coming from the complex system under study.

Since the last two decades, the Non Destructive Testing (NDT) community developed, at the research level, a new class of signal processing tools for extracting the nonlinear signature of damaged materials. The Nonlinear Elastic Waves Spectroscopy (NEWS) methods was developed with signal processing improved for extracting, from the complex materials and systems, new deterministic components. These components allow information about the nonlinearity of medium: harmonics and modulation for weak (classical) nonlinearity; slow dynamics, sub-harmonics, hysteresis and memory effects for strong (non classical) nonlinearity observed in mesoscopic materials.

The huge variety of information extracted from this small stochastic part of the response coming from a complex system induces an increase of uncertainty associate to the linear part. This linear part, with its

underlying hypothesis of stationarity and determinism, should be consequently associated to a grater uncertainty if the system under study presents intrinsically a complex structure with mesoscopic properties, memory effects, conditioning, and ageing. Of course, these properties are breaking now the stationarity hypothesis implicitly assumed in any linear signal processing, since linear systems theory dominates the field of engineering.

In this paper, we will present the basis of any nonlinear signal processing with the example of NEWS signal processing methods for NDT applications. Complex properties of damaged materials will be presented with the Preisach-Mayergoyz space (PM space) phenomenological approach. The consequences of the PM space modeling of mesoscopic materials will be highlighted with two examples: ultrasonic measurements in damaged materials, and electronic characterizations of complex network of hysteresis relays. This phenomenologically based approach is under investigation for the conception of new kind of system identification, validated and patented for complex biological systems such as bone, tooth[3] or complex manufactured products coming from the bio and agronomy industry. The objective to extend this modern approach to skin and human brain, from whose memory effects are currently admitted, gives to this approach a promising future for modern engineering, and medical imaging.

Finally, since the structuration of complex social and professional organization is known to exhibit memory effects, conditioning, local and global synchronization, hysteresis, threshold effects, amplitude dependance, and saturation at various states, an extension of this mesoscopic signal processing will be introduced in order to quantify the new proportion of stochasticity in the (nonlinear) response of a complex system. Since stochastics signal are actually produced by deterministic mesoscopic systems that are capable of nonlinear stochastic responses, their behavior should be associated to invariant properties, such as symmetries like Time Reversal (TR). For example, the stability of such mesoscopic system is also conditioned by a complex skeleton of elementary rules or elements. Under external excitations, nonlinear systems (or complex organizations) can produce non deterministic responses which increases the stochastic part with a non intuitive proportion that needs to be considered in modern engineering of organization, and social monitoring.

The consequence is a pragmatic analysis swarming by phenomenological approaches in the family of PM models. The accurate extracted information coming from such systems needs to be associated to the symmetry of the underlying mesoscopic structure with respect to scaling effects responses.

Key words: Nonlinear signal processing, Mesoscopic medium, Stochasticity.

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Mechanical and ultrasound testing of human skin viscoelasticity in vivo

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Abstract

The skin is a viscoelastic, non homogeneous and anisotropic material and combines the mechanical properties of a viscous solid and an elastic solid. The main goal of the studying is the comprehension and prediction of the skin physical behavior. For this, a mechanical model has been already proposed, and a device called extensometer, which is also already realized, enables to apply a progressive load of the skin. The objective is to identify and evaluate all the nonlinear parameters, with several different techniques[1, 4, 3]. This tool enables to measure these mechanical features. However, it is not convenient and needs some improvements. This one needs to make it more portable, and to have a more accurate and interactive control with LabVIEW. The tasks presented within this work are:

- Study the existing Matlab control program for mechanical properties measurement
- Program new mechanical devices controlled by LabVIEW
- Create and develop a new user interface in LabVIEW

Key words: Ultrasound, Skin, Viscoelasticity.

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Classification and Separation of AE Signal Signature - Divergence Based Approach

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Abstract

This paper engages in the classification of acoustic emission (AE) signals by means of different classification methods, e.g. Fuzzy method, Model-based method, Support Vector Machine. We deal also with application of ϕ-divergence in the field of classification. We propose an incorporation of the ϕ-divergence both as a part of classification method and also as a parameter for classification. By means of divergence from different parts of spectrum, different parameters are extracted and more compact clusters are identified. In this paper, we compare various methods of classification with and without incorporation of ϕ-divergence and we apply them to our laboratory AE data and coming from other physical experiments too.

Key words: acoustic emission; classification; ϕ-divergence.

Acknowledgement

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Analysis and properties of the robustified total least squares problem

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Abstract

The contribution deals with the robust estimation of parameter β in overdetermined sets of linear equations $X\beta \approx Y$ when errors and outliers occur in all data. The classical total least squares (TLS) method was introduced into numerical mathematics by Golub and Van Loan [1] and is strongly based on singular value decomposition. The consistency of such a estimator was proved for a univariate homoscedastic model by Gallo [3] and for multivariate homoscedastic model by Glesser [2]. These results were generalized by Kukush and Van Huffel [6]. The method of TLS asserts itself gradually in statistics and data analysis. In the contribution is summarizes the development of the classical TLS estimator and of its robustified version, which gives relevant results, when outliers in datasets occur. Primarily the computation aspects, algorithms and consistency is mentioned.

Key words: Total least squares (TLS), Errors in variables, Robust statistics, Trimming, Weighting.

Acknowledgement

This work was supported by the grants SGS12/197/OHK4/3T/14 and MSMT INGO-II LG12020.

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Evaluation of Screening Mammograms by Local Structural Mixture Models

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Abstract

The recently proposed evaluation of screening mammograms based on local statistical model [1] is considered. We describe the local statistical properties of mammograms by a mixture of Gaussian densities defined on the pixel-space of a small scanning window. We estimate the mixture model by EM algorithm from data obtained by scanning the mammogram with the search window. The value of the estimated Gaussian mixture is calculated at all window positions and the corresponding log-likelihood values are displayed as grey levels at the respective window centers. The resulting log-likelihood image closely correlates with the structural details of the original mammogram and emphasizes unusual suspect regions as dark locations (cf. [1]). In this paper we try to enhance log-likelihood images by using the structural mixture model [2] the components of which can be defined on different subspaces. By excluding the less informative noisy variables in the components we obtain more clearly defined contour lines of suspect findings. Simultaneously, without increasing the computational complexity, we can increase the window size to capture larger details of the mammogram. Formally, the method is applicable in monitoring systems, e.g. to identify unusual or unsafe situations in the state space.

Key words: Screening mammography; texture information; local statistical model; structural Gaussian mixture; log-likelihood image.

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Simulation Study of Minimum Distance Density Estimates

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Abstract

This contribution focuses on minimum distance estimates of the true density on the real line. We are interested in consistency of these estimates and their robustness. We deal with the Kolmogorov estimates, which are proven to be consistent in the L_1-norm. The Kolmogorov distance is known to be in some sense robust similarly as the Cramér–von Mises distance that is frequently used in statistical estimation and hypothesis testing framework. In the previous work [2] we defined two modifications of Cramér–von Mises distance, namely Generalized Cramér–von Mises (GCM) distance by replacing second power in the original formula by a general power, and the so called Kolmogorov–Cramér (KC) distance summing up only a certain number of the greatest empirical differences from the model (the number of differences is taken either fixed or dependent on sample sizes), e.g. $\mathrm{GCM} = \frac{1}{n}\sum_{i=1}^{n}(F_n(x_i) - F(x_i))^{p/q}$, $\mathrm{KC} = \frac{1}{|J|}\sum_{i\in J}(F_n(x_i) - F(x_i))^{p/q}$. We introduce a wide class of modifications of the Kolmogorov–Cramér distance by implementing data-based weight functions, random selecting of differences to be summed up, and using various coefficient modifications. All these new estimates are defined to preserve consistency and simultaneously to have better robust properties than the Kolmogorov estimate. We perform an extensive simulation study to compare robustness of newly introduced estimates with the original Kolmogorov and Cramér–von Mises estimates. Various sample sizes (form 10 to 500) were generated and we study both non-contaminated and contaminated case with contamination proportion ranged from 0.01 to 0.35. Regarding the robustness, we compare bias of the estimated parameter from the true parameter. As our simulation shows, newly defined estimates possess considerably better robust behavior than the Kolmogorov estimate and, moreover, they preserve consistency even under rather moderate level of contamination.

Key words: Minimum distance estimator; consistency; robustness; Cramér–von Mises distance.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Measurement of acoustic emission on helicopter gearbox

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Abstract

The application of acoustic emission in condition monitoring of rotating machinery is gaining great significance in recent years. It provides early fault detection and thus helps to avoid major failures with catastrophic consequences. This short contribution briefly describes acoustic emission, vibrations and its use in condition monitoring. Next, it presents results of an experiment on helicopter gearbox in healthy state. Four AE sensors were placed on the gearbox and AE activity was continuously recorded for almost one hour with sampling frequency of 2 MHz. Furthermore, the data were partly processed in time, frequency and time-frequency domain. The results show the possibility of fault detection. This has to be confirmed in future experiments on gearboxes with defects.

Key words: acoustic emission; condition monitoring; helicopter gearbox.

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Divergence-based homogeneity tests for dependent data

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Abstract

The problem of testing homogeneity in contingency tables when the data are spatially correlated is considered. We derive statistics defined as divergences between unrestricted and restricted estimated joint cell probabilities and we show that they are asymptotically distributed as linear combinations of chi-square random variables under the null hypothesis of homogeneity. Monte Carlo simulation experiments are carried out to investigate the behavior of the new divergence test statistics and to make comparisons with the statistics that do not take into account the spatial correlation. We show that some of the introduced divergence test statistics have a significantly better behavior than the classical chi-square one for the problem under consideration when we compare them on the basis of the simulated sizes and powers.

Key words: Test of homogeneity; Divergence statistics; Chi-square statistic; Spatial data.

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Zero-range processes in traffic flow modeling - microstructural study

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Abstract

The simplicity of cellular models based mostly on exclusion processes re-opened the question of real-time traffic flow modeling and prediction. Many CA models and modifications appeared trying to reproduce the fundamental macroscopic and/or microscopic characteristics of traffic flow.

The space-discrete nature of CA causes sufficient problems to enhance the microscopic correspondence of the model behaviour to the real traffic. Complicated structure of inter-particle interaction disables the analytical solvability of the system. On the other hand, keeping the nearest-neighbour interaction averts the "real-like" behaviour on the microstructural bases. To handle this issue, several mappings of complex long-ranged processes on the zero-ranged processes were introduced (see references [1, 2, 3]). The aim of the contribution is to discuss the microstructural behaviour of these models focusing on the headway distribution. Furthermore, new idea of nearest-particle interaction process is introduced, reflecting the microstructure of the real system. The analytical solvability is maintained while smoothing the size of the lattice cell.

Key words: Zero-range process; cellular model; headway-distribution.

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Random regression coefficient area level models

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Abstract

The Fay-Herriot (FH) model is a basic area level model. It is a special instance of the linear mixed models with fixed and random effects. In this contribution we introduce the generalized FH model which, unlike the classical FH model, includes random regression coefficients to treat situations where small areas are divided into several groups and where direct estimators of the variable of interest follow different relation depending on group. We use REML (Restricted Maximum Likelihood) method to obtain estimates of model parameters. We provide formulas to calculate EBLUP (Empirical Best Linear Unbiased Predictor) of the variable of interest and to estimate its mean squared error. Simulation experiments are presented to investigate the behaviour of the REML estimates and to show the accuracy of the EBLUPs calculated by the proposed model. Finally, the FH model and its proposed generalization are compared. The FH model proves to be very adaptable to the data generated by the model with random regression coefficients.

Key words: EBLUP; Fay-Herriot model; Linear mixed models; Area level models; REML.

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Location of acoustic emission sources by artificial neural networks

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Abstract

Sufficiently precise knowledge about localization of acoustic emission (AE) sources is a basic requirement in AE analysis and consequent damage mechanism characterization. The calculation of source location is mostly based on arrival times differences of the signals recorded by different transducers and application of the triangulation algorithm. The localization procedures using artificial neural networks (ANN) represent today more effective, alternative approach to classical triangulation algorithms. Artificial neural networks are able to estimates the AE source location also by processing basic signal parameters instead of arrival time differences. Nevertheless, their application possibilities are limited due to several reasons. The main problems are in the collecting of sufficiently extensive training and testing data sets together with the non-portability of particular trained network to any other object. To overcome both limitations, the new AE source location method using so-called signal arrival time profiles was recently proposed. The paper introduces a brief summary of above mentioned methods.

Key words: Acoustic emission; source location; artificial neural network; arrival time profiles.

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Verlet method for traffic simulation

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Abstract

The work is focused on a traffic model based on one-dimensional short-range thermodynamic partical gas, with given form of the repulsive potential, situated in the thermal bath. The main goal is to introduce the proper scheme for numerical integration of this modified Dyson gas. Desired method should be time invariant, energy conserving and should preserve the symplectic structure of the phase space. As an appropriate beginning, the algorithm named Verlet integration was chosen. This numerical method frequently used to integrate Newton's equations of motion, and so to calculate trajectories of particles in molecular dynamics simulations, offers great stability and satisfies mentioned conditions. The next step is to explore the possibility of using the modifying called the adaptive Verlet method. This approach is based on a time reparametrization, which led to improvement in the behavior of the numerical method..

Key words: verlet integration; dyson gas; traffic modeling.

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A comparison of Fay-Herriot and logistic regression models

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Abstract

Nowadays, a demand for reliable estimation in small areas is increasing. A lot of statistical surveys are designed e.g. on state level and sample size in particular territories or districts is not large enough for direct estimation. Small area estimation deals with this problem and offers suitable models. In this report, Fay-Herriot and logistic regression models are considered. Fay-Herriot model is the most used one and it is a basic model at area level. It is a linear mixed model i.e. with fixed and random effects. Logistic model is a generalized linear model and it is used for binary data at individual level. We introduce these two approaches and in simulation experiment both models are applied. As a conclusion, a comparison between them is shown.

Key words: Small area; Fay-Herriot model; Logistic regression model.

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Mechanical and ultrasound testing of human skin in vivo

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Abstract

The propagation of acoustic waves is directly related to the properties of a material. It is interesting to study these waves to characterize the skin. The objective is to identify and evaluate all the nonlinear parameters, with several different techniques [1, 4, 3]. The technique is based on ultrasound coupled with mechanical stress inducing a stretching of the skin. Ultrasonic measurement require complex measurement device controlled by LabVIEW. The next step of the project is to create a complete system that can be compact. This system will be controlled by a graphical Interface in LabVIEW. The objectives of the project are:

- Study the existing Matlab control programme for ultrasonic measurement
- Create a new program with LabVIEW to control all the experiment process (Send SHIRP signal, using time reversal method, display all results,)
- Create a user friendly GUI

Key words: Ultrasound, Skin, Chirp coded signal processing.

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Matrix Reloaded

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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

$$\wp(s) = A\Theta(s)s^{\beta}e^{-Bs}, \quad A = A(\beta),\ B = B(\beta).$$

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

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

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 (). We will demostrate a possible way how to attain it.

Key words: Random Matrix Theory; Mathematical modeling of traffic flows; Level spacing.

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Testing of robustness and efficiency of Rnyi divergence estimators of probability densities

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Abstract

In this contribution we study Rnyi pseudodistance estimators which are based on minimization of information-theoretic divergences between empirical and hypothetical probability distribution. These distances are more robust (than e.g. MLE estimators) against outliers and other measurement errors potentially present in the data sets. Robustness of these estimators is described by influence function. In [1] and [4] authors found explicit formulas for enumeration of Rnyi distances in normal families and for their influence functions. We focus on finding explicit formulas for other families (Weibull, Cauchy, Exponential) and finding influence functions for these estimators. We perform computer simulations for pseudorandom contaminated and uncontaminated data sets, different sample sizes and different Rnyi distance parameters.

Key words: Rnyi pseudodistances; $\phi-$divergences; robustness; minimum distance estimators.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Mathematical Techniques for Nonlinearity Structural Effects in Materials - AE Detection, Classification, Localization, Phi-Divergence Applications

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Abstract

We focus on the detection, classification and localization of acoustic emission (AE) sources by means of various mathematical and statistical methods (DM, N-R, PM Space, Divergences,...). For example, the acoustic signals are separated by suitable parameters obtained directly from the signals and from the normed frequency spectra.

The phi-divergence distance measures are employed as the additional signal spectrum attribute. We deal with a simple method of construction of phi-divergences and we introduce several modifications such as generalized LeCam, Hellinger, and Breigman divergences. We are concerned with the efficient set of classification parameters while testing the quality of classification, see Figure 1. We combine both the main approaches described above, i.e. the generalized phi-divergences and the distribution mixture method. The advantage of the combined method is that it is able to assess the number of clusters of the signals and simultaneously it is robust in the sense that it ignores sparse outliers that would distort either the standard statistical estimates or classical non-statistical approach. For AE source localization we employ the numerical algorithms to minimize a distance functional Euclidean measure. For PM space modeling we proposed some new 2-D distributions describing the structure of the material under consideration.

Consequently, we verify all these methods for nonlinearity AE detection on both laboratory data sets and also for the experimental design of steel material. All processing laboratory measured acoustic signals were detected through the piezo-ceramic sensors attached to the thin metal plate and emitted signals were measured and stored by means of measuring device Xedo5 in 12-bit accuracy and 4 MHz sampling rate. We conclude that these above mentioned and newly applied families of divergences (e.g. see [6] in details) open new research possibilities in the area of statistical treatment of acoustic emission sources.

Key words: Nonlinear effects in materials; Mass structure; Phi-divergences; Separation techniques.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Change point detection algorithms for complex physical dynamical systems

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Abstract

The target of this contribution is to present an integrated overview of algorithms which could be used for change point detection of any physical dynamical system, e.g. in acoustic system or for the particle detection in accelerated physics. Furthermore we want to show a possible improvent of the localization of the source of acoustic emission while using these algoritms instead of the well-known treshold level method. Among these algoritms we study the methods based on hypothesis testing by probability ratio, which are described in [1], the algorithm based on the Schwarz Information Criteria (SIC) [2], the method using Singular Spectral Analysis (SSA) [3], and finally the algorithms based on the estimation of autoregressive stochastic processes (time series)

and the consecutive χ^2-test [4]. As an example, applying these algorithms, we want to show some possible improvements of numerical iterative localization techniques for detecting the source of the acoustic emission. We consider the linear source localization based on the signals emitted and we develop the mechanisms for the algorithmic testing concerning more complex physical experimental setup such as the particle detection in accelerated physics.

Key words: Change point detection; Singnal analysis; Acoustic emission.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Correlation Analysis of Traffic Data

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Abstract

In this article, the usage of the thermo-dynamical traffic model, which was lately improved to the mixed distribution semi-Poisson model with regard to the traffic data correlation analysis, will be discussed. Attention will be predominantly focused on the independence between headways and velocities. The goal of this paper is a discussion and verification of the assumptions for the thermo-dynamical traffic model, with suggestions for improvements and modification of the model for traffic modelling.

Key words: Thermodynamical traffic model, semi-Poisson, correlation analysis, phase-space, independence, headway.

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Small area estimation of the poverty incidence in Spanish provinces

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Abstract

The talk is divided in two parts. The first part has an introductory character in order to describe the small area estimation problem and the direct estimator. A discussion on the need of introducing models to borrow strength from time will be given. The second part is devoted to describe the temporal area-level models developed in the European project SAMPLE (http://www.sample-project.eu/). In addition to theoretical considerations, the results of some simulations experiments are presented. The experiments are designed to investigate the behaviour of the introduced statistical methodology: fitting algorithms, EBLUP-type estimators and the bootstrap method for estimating mean squared errors. An application to Spanish Living Condition Survey data is also presented. The scope of the application is to estimate poverty indicators in Spanish provinces (small areas). The application is taken from Esteban et al. (2012). Finally, some conclusions are given.

Key words: Small area estimation; area-level models; time correlation; poverty measures.

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L_2-Distance and ϕ-Divergence Approaches to the Key Mass Structure Detection by Means of Nonclassical Nonlinear PM Space Identification

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Abstract

In this contribution the PM space hysteresis model is introduced as a tool for describing non-classical nonlinear hysteresis materials, for which the hysteresis is one of the key properties. It became more important during the last years in the field of Nonlinear Elastic Wave Spectroscopy (NEWS) with the growing number of NDT technologies or in elastic collisions of elementary particles in accelerated physics. Recently, an active research has been conducted for the modeling of nonclassical nonlinear effects in biological tissues using memory based phenomenological approaches [1, 2]. Also the memristive effects could play a significant role in the complex nonlinear properties of biomaterials, such as tooth [3] or skin [4]. We will focus on the multiscale hysteresis represented by the system of electromagnetic relays, which is one of the basic type of hysteresis in electronics. We will presents our results which has been carried out in the laboratory at ENI Val de Loire in Blois, France. Electronic set-up has been made for studying electronic hysteresis with the objective to have experimentally results for PM space density identification. Coded excitations using chirp-like short-time coded signal and modulated excitations have been been applied in order to test the inversion algorithm. Optimized excitations have been studied in the frequency range of $f_0 \in [300mHz, 3Hz]$ and with amplitude $A = 28V$. Several hysteresis curves have been obtained experimentally. These results was used for PM space density identification [5] under the classical L_2-space or using special statistical distances called ϕ-divergences originated from information theory. Employing these extended ϕ-divergences [6] we achieve the PM density identification which is more robust against outliers and other measurement errors potentially present in the data sets.

Key words: Nonlinear nonclassical materials; Mass structure; PM space; L-2 space; Phi-divergences; Density identification; Electromagnetic relays.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Analysis of traffic data from a non-signalized intersection and design of a cellular model for the vehicle movement in the vicinity of a non-signalized crossroad

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Abstract

One way to simulate traffic flow near a crossroad is to use principles of a thermodynamic modeling. Associated model is based on a thermodynamic statistic gas with a certain potential energy (usually power-law). Such a model belongs to a family of microscopic models which means that moves of individual vehicles are simulated. Advantage of this approach lies in fact that the statistic characteristics of data generated by the model are the same as those gauged in real-world data. The model of a simple crossroad presented here is based on two intersecting circles. The circles intersect each other in one point which represents the actual crossroad. Particles on the circles correspond to vehicles. The main question is: which potential to choose? This question will be addressed by analyzing real data from a simple non-signalized intersection.

Key words: thermodynamic gas; non-signalized intersection; cellular model.

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On partial regularity of solutions to the quasilinear parabolic systems of PDEs up to the boundary

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Abstract

This contribution deals with partial regularity of the solutions to the initial-boundary value problems for quasilinear parabolic systems in the Hilbert space setting. Despite the fact that the heat equation has a smoothing property, the solutions of quasilinear parabolic systems are not smooth in general. It is possible to construct a quasilinear parabolic system having smooth coefficients with a weak solution that starts as a smooth one at $t = 0$, stays bounded and develops a discontinuity in some moment $t > 0$ [1]. However, it is possible to prove (under suitable assumptions on the system's coefficients and boundary) that the weak solutions of quasilinear parabolic systems are are Hölder continuous on an open subset of the domain with small complement (with zero Lebesgue measure). Moreover, it is possible to demonstrate, that the solution is Hölder continuous in the vicinity of almost all (in the sense of an appropriate parabolic Hausdorff measure) boundary points. In this contribution, we will outline a proof of Hölder continuity of the solution for the boundary points that satisfy certain regularity condition. Analogous results for interior points can then be easily obtained. The proof is based on the method of A-caloric functions [2, 3]. The results presented are not new but they rather follow as a special case from more general results obtained in [4] and [5].

Key words: parabolic systems; partial regularity; A-caloric functions.

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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 N 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 p 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.

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Car-following model for departure headways at signalized intersections

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Abstract

Recently many researches investigate traffic microstructure at signalized intersections. There exists models based on thermodynamical gas, but they predict the inter-vehicle gaps only (see [3] for details). We will focus our attention on modeling car dynamics when leaving signalized intersection. A modified car-following model from the driver's perspective, firstly investigated in [2], will be presented and statisticaly analysed. We will show that propability density $p(t|\beta)$ for departure headways yielding by the model follows the distribution

$$p(t|\beta) = \theta(t) A \mathrm{e}^{-\frac{\beta}{t}} \mathrm{e}^{-Dt}\,, \quad A = A(\beta)\,, \quad D = D(\beta)\,, \tag{1}$$

analytically derived for local thermodynamical model with socio-physical repulsion among succeding vehicles. Vehicular dynamics, i.e. driving modes and updating rules for the model will be discused in detail. Then different gap initialization and steady state of the model will be analysed. In the end the results and plans for future research will be presented.

Key words: Car-following; Model; Headways; Intersections.

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The influence of the pseudorandom number generators on the spectrum properties of the pseudorandom matrices

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Abstract

The random matrix theory (RMT) has been studied for over 20 years and has a lot of practical applications in various fields. The scientists are trying to find corresponding results of their work within the RMT. More precisely, they compare the spectra of the random matrices and their spacing distribution with the RMT predictions. However, these predictions depend not only on the type of the generated matrix but on the pseudorandom number generator (PRNG) which is used for generating the matrix elements, as well.

The subject of our interest are the eigenvalue distribution of the Gaussian orthogonal ensemble (GOE) and of the Gaussian unitary ensemble (GUE) and the distribution of the spacings between the eigenvalues of the mentioned matrices. Since the elements of GOE and GUE are normally distributed several PRNGs

for normal distribution are introduced. Gaussian generators are based on the transformation of the random number from uniform distribution. The PRNGs for uniform distribution are presented, as well. As a result, various combinations of these generators can be used and this report confronts the influence of these combinations on the matrix spectrum. In addition, the Wigner surmise for spacing distribution is verified.

Key words: Pseudorandom number generators; GOE; GUE.

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Suggestion of thermal-like transport model for two-lane traffic

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Abstract

No satisfying transport model generating correct fundamental diagrams and lane usage for multilane traffic with asymmetric lane changing rules (right-lane preference and no right-lane overtaking) has been found by today. This article suggests a thermal-like transport model based on Metropolis algorithm and an idea that vehicles velocities are chosen randomly from a scale distribution. There are showed simulation results for several different velocity functions. We try to determine conditions of the suggested model that is suitable for two-lane traffic.

Key words: Thermal-like model; two-lane traffic.

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Improvement of time reversal method with visual sensors

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Abstract

Using time reversal mirror in non destructive testing is a promising method that allows detecting microcracks inside the structure of the materials. However, due to restricted number of transducers used during the measurement, we cannot determine the exact position of the crack. There is a will to develop new more sophisticated imaging method that would allow us better targeting. For that the process of data analyzing should be changed in order to obtain more information that could be involved during the process of imaging. This should lead to more complex and more accurate pictures. In my presentation I will briefly summarize contemporary imaging method. Then I will discuss its disadvantages and finally present technique that could result in desired goals. This technique exploits theory of virtual sensors. These are results of multipath wave propagation.

Key words: time reversal mirror; non-destructive testing; virtual sensor.

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Ultrasonic Measurement of Skin Surface Deformation

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Abstract

This paper describes a development of a system for ultrasonic measurement of a human skin surface deformation *in-vivo*. The basic idea of the system use is that the evaluation of the skin surface deformation around a joint should provide information about a flexure range of the joint itself.

A measuring method is based on pulse-echo measurements of an ultrasonic wave propagating in the skin sufrace. The ultrasonic wave is transmitted and received using a pair of piezoelectric transducers that are fixed on the skin surface. The deformation of the skin surface is evaluated from changes of a distance between the ultrasonic transducers.

The developed measurement system consists of self designed transmitting and receiving circuits for evaluation of the distance between ultrasonic transducers. The system is PIC® microprocessor controlled and enables data transfer via USB interface.

The system has been tested and considered as the working prototype. Further development will be focused on improvement of the measuring method itself and technique of the joint flexure range evaluation.

Key words: Ultrasound; Skin surface deformation; Joint flexure.

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Stability and Robustness of Signal Classification Techniques for Physical Data Sets

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Abstract

We deal with various classification methods in data sets originated from different physical experiments. It can be the case of accelerated particles data in proton-antiproton collisions (Fermilab) or applications of acoustic emission detection in nondestructive testing. The acoustic emission emerges due to the cracks, fatigues or possibly other nonlinear material effects. Signals of the acoustic emission may differ by types of materials and through these differences the signals can be assigned to material which they originate from. The classification of signals of acoustic emission can be done by means of different classification methods, in our case by means of Model-Based Clustering method (MBC). In this work we also test the suitability of chosen parameters which were used for identification of acoustic emission sources [1, 2]. The method is applied to real experimental data.

Key words: Acoustic emission, Model-Based clustering.

Acknowledgment

This work was supported by the grants SGS12/197/OHK4/3T/14, GACR P202/10/0618, MSMT INGO-II LG12020, and by the MSMT research program under the contract MSM 6840770039.

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Acoustic Emission Crack Detection by Means of Iterative Procedures Based on Geodetics

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Abstract

We deal with the Acoustic Emission (AE) principle as a Nondestructive Testing (NDT) method for the structural monitoring to achieve the target of precise geodetic localization of defects on the surfaces of solid bodies. We suppose the surfaces are mathematically described as a conjunction of several simpler parametric shapes with underlying mutual intersected one-dimensional areas. We use the Newton-Raphson procedure and we propose and test a few algorithmic improvements. On this basis we develop new efficient variants of localization algorithms employing Direct Search Methods (Compass algorithm, Reduced Newton method and Nelder-Mead method) for minimizing distinctions between real measured time differences and length differences of the computed geodetic curves. The whole procedure is applied to the real industrial data concerning quick and exact

localization of the acoustic emission source on pressure vessel and also verified within our experiment for the Anodized Aluminium Watering Can under consideration.

Key words: Acoustic Emission, Geodetic Curves, Newton-Raphson method, Direct Search methods.

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