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Acoustic emission : localization of defects on a surface using geodesic curves theory

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Abstract

Acoustic Emission Testing (AET) has become a recognize nondestructive test method commonly used to detect and locate defects in mechanically loaded structures and components. Although the current methods used to locate those defects grant us a precision of roughly one square meter, it is possible to improve this precision by using the theory of differential geometry, i.e. by solving the geodesic equations which are known to be the shortest path between two points in a curved space, that is, in our case, between a sensor and a defect on a shape like a cylinder. We can solve the the system of differential equations by using a functional iteration method then the Newton-Raphson method, assuming that we are given a first approximate path. When we have a complex structure which can be described as several simpler shapes, the problem becomes the computing time : we must find a geodesic crossing intersections, and for that we have to test a lot of them, and select the shortest one. The more geodesic paths we test, the longer it takes.

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Mechanical and ultrasond testing of human skin in vivo

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Abstract

Ultrasonic measurement require complex measurement device controlled by Matlab. Parameters are written directly in the source code. Run the appropriate routine according to the experiment process (direct response measurement, Time-Reversal, ...). This system is insufficient and need improving. The objectives of the project are:

- Study the existing Matlab control programme for ultrasonic measurement
- Create new procedures for different experiment using the existing routines
- Create a user friendly GUI

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Minimum pseudodistance estimators

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Abstract

We introduce minimum power and Rényi pseudodistance estimators. We study and compare some general properties of these estimators such as influence curves, our main focus will be on estimation of normal location and scale. In the second part we numerically compare robust properties of minimum power and Rényi pseudodistance estimators for different parameters α and also compare them with minimum Hellinger and Kolmogorov distance estimators and minimum LeCam divergence estimator. This comparison is done in the normal family under different level of contamination.

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Statistical Methods in Signal Processing and Discrimination

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Abstract

We deal with the classification of acoustic emission by means of methods of clustering, e.g. Fuzzy Clustering, Model-Based Clustering or Support Vector Machines. Each of these methods belongs to a different group of methods of classification: Fuzzy Clustering is based on the optimization of an objective function; Model-Based Clustering consists of two parts – Agglomerative Clustering and the EM algorithm – and Support Vector Machines search for optimal separating hyperplanes between clusters. The signals are compared by means of suitable parameters. These parameters are obtained from signals and from normed spectra. We also used ϕ-divergence between normed spectra of signals as one of parameters for the comparison of signals. We are concerned with former methods of clustering, the comparison of these methods and the selection of suitable parameters for classification. Testing of the classification methods is done by means of three experiments in the area of acoustic emission, with laboratory data and also with data from real life.

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Robust regression methods when orthogonality condition is breaking

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Abstract

Classical regression estimators, such as ordinary least squares, are sensitive to occurrence of outliers and are not consistent when the orthogonality condition fails. There have been several robust estimators that can cope with this problem. The development of instrumental weighted variables (IWV), the robust version of instrumental variables methods, is reviewed and extended. Several different algorithms, evaluating the estimation by IWV, are proposed. The alternative approach in regression methods when orthogonality condition is breaking and both independent and dependent variables are considered to be measured with errors is called total least squares (TLS) method. The existence and uniqueness of the solution is discussed and two different approaches of calculation are described. Finally the robustified version of TLS based on the idea of downweighting the influential points is presented and the large sample properties of this estimator is discussed.

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Performances of modified power divergence estimators in normal models

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Abstract

We shall present the key results of extensive simulation study of several types of point estimators based on minimization of information-theoretic divergences between empirical and hypothetical distribution. We face the problem that the continuous family and the family of empirical distributions are measure-theoretically orthogonal, therefore the ϕ-divergence is always equal to its upper bound and the minimum ϕ-divergence estimates are trivial. Broniatowski and Vajda in [1] proposed several modifications of the minimum divergence rule to provide another solution to the above mentioned problem. They alter the traditional ϕ-divergences into *subdivergences* and *superdivergences* and define *maximum subdivergence estimators with escort parameter* θ and *minimum superdivergence estimators*. The main interest of our research ([3]) was to examine these modifications in practical use as to the consistency, robustness and efficiency of the estimators. We focus on the well known family of power divergences parametrized by α in the normal distribution model. We run a comparative computer simulation for several randomly selected contaminated and uncontaminated data sets, and we study the behavior of estimators for different sample sizes and different ϕ-divergence parameters.

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Consistency and Robustness of Minimum Distance Estimates

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Abstract

Minimum distance density estimates (MDE) are considered. Via numerical simulation, robustness and consistency of many types of MDE are examined. We consider Kolmogorov, Lévy, discrepancy, and Cramer–von Misses distances. For all but last distances we have proven consistency of the order $n^{-1/2}$ in L_1–norm if the sample is non–contaminated. Graphs and tables for contaminated case are presented and discussed. Further, two new types of MDE are introduced, namely, with generalized Cramer–von Mises (GCM) distance. Both types of GCM estimates are simulated and results are presented and discussed. As results of simulation show, the new defined estimates possess some robustness and consistency even for heavily contaminated distributions (35% contamination).

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Application of an area level model to small area estimation

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Abstract

Linear mixed models are widely used in statistics and their applications to small area estimation (SAE) is discussed in Rao (2003) and Jiang and Lahiri (2006). The basic area level linear mixed model was introduced to SAE by Fay and Herriot (1979).

In this contribution we extend the Fay-Herriot model to an area level linear regression model with random intercepts having one of two possible variances. Estimation procedures for the variance components and regression parameters are considered and empirical best linear unbiased predictors (EBLUP) of domain parameters are derived. The approximation given by Prasad and Rao (1990) is applied to obtain estimators of the mean squared errors of the EBLUP estimates.

Monte Carlo simulation experiments are presented to illustrate the gain of precision obtained by using the proposed model and to get some practical conclusions. A motivating application to Spanish Labour Force Survey data is also given.

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The totally asymmetric simple exclusion process in two–dimensional finite lattice, comparison of density profiles

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Abstract

A two–dimensional model based on the totally asymmetric exclusion process is introduced. It's dynamics is inspired by pedestrian movement. We come out of the one–dimensional TASEP with open boundaries defined on a finite lattice of N sites. This model is solvable by means of the Matrix Product Ansatz method, which gives exact formulas for density profiles and phase diagram containing three phases, maximal current, low- and high–density phase; for both time continuous dynamics and discrete parallel updates. We define similar dynamics on a rectangle lattice of $M \times N$ sites with open boundaries. Several update procedures are discussed, and the permutation–parallel update is introduced. Via computer simulations the average density in steady state has been studied, and similar behavior to the one dimensional model has been observed. We have identified the same three phases and the same shape of the transition line between the low- and high–density phase. Finally, an idea of generalization for two particle species model is presented.

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Analytical derivation of spectral rigidity for thermodynamical traffic gas

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Abstract

This paper deals with one-dimensional short-range thermodynamic partical gas situated in thermal bath. Examinated is the exact form of number variance $\Delta_n(L)$. The main aim represents analytical derivation of the expression of the mentioned function. To achieve this goal following equation will be used

$$\Delta_n(L) = L - 2\int_0^L (L-s)\big(1 - R_2(s)\big)\mathrm{d}s.$$

As can be seen the form of the two-point correlation function $R_2(s)$ is needed. It relates closely to the n-th nearest-neighbor spacing distribution $P(n,r)$. The special case of this function represents nearest-neighbor spacing distribution $P(r)$, the form of which has been already calculated.

Also the supposed general form of the desired function is known. The number variance could be approximated by a line

$$\Delta_n(L) = \chi L + \gamma.$$

Now, the task is to find the expression of two coefficients χ and γ. After gaining the form of number variance, it will be compared with outputs of numeric model.

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Multi-dimensional alternative of thermodynamic transport gas - a challenge for social modeling

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Abstract

As well known, the thermodynamical approaches (originally developed for purposes of statistical physics) can be successfully utilized in traffic modeling. Such a thermal perspective is usually used for randomization of deterministic systems, which means that in our investigations the thermodynamical approach is used to describe the individuality of each agent in the system observed (vehicular traffic, movement of animals, movement of pedestrians). We introduce a socio-physical interpretation of the Hamiltonian for the above-mentioned social agent-systems and show possible applications for modeling of a group of pedestrians moving in a corridor.

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Stochastic Convergences in Divergences

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Abstract

We introduce information-based statistical divergences in frame of so-called score functions and provide their connections to some well-known metric and nonmetric distances such as Kolmogorov distance, Total Variation, Hellinger divergence, Pearson statistics, class of Power divergences, etc. The examples of newly extended parametric families of ϕ–divergences will be given together with several theorems concerning sufficient or necessary conditions for selected metric properties of divergences, i.e. reflexivity, symmetry or triangle inequality. Further, we deal with the statistical estimation concept both in parametric and nonparametric manner and show the importance of stochastic convergence in divergences previously introduced. The domination relations between divergences play the main role for deriving the stochastic consistency of resulting estimators, so we define uniform, classical and local dominations with respect to a given (metric) divergence and we provide the application to minimum Kolmogorov distance type estimators. Further theoretical aspects of metrics and divergences related to consistency and robustness with examples will be performed in following successive contributions where also the real practical application to material crack diagnostics is treated.

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Derivation of time-headway distribution of thermodynamical traffic model

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Abstract

Nowadays, quite an attention is paid to discreet traffic models (ASEP, Nagel-Schreckenberg,...). Even though, it is appropriately simulating traffic, its microscopic features does not correspond to real data. That is why we introduce Dyson-Coulomb gas approach, which seems to be in good accordance with the real traffic samples. From recent researches it seems, that space-distribution is not sufficient characteristic of traffic models. By means of Laplace transformation and theory of asymptotic expansions important feature of thermodynamical model is derived - time-distribution function, which seems more appropriate to describe traffic. We confront this distribution to real data samples from highways.

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Model of the Traffic Flow in the Vicinity of a Signal-Controlled Crossroad Based on Dyson's Thermodynamic Gas

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Abstract

Dyson's thermodynamic gas presents us a way to simulate a flow of vehicles. Dyson's gas is represented by particles located on a line or a circle. As the time is passing, the particles interact with each other and change their positions in order to lower the total potential energy of the gas. Development of the gas with a certain temperature can be simulated by the Metropolis algorithm based on the Monte Carlo method. Particles, which the gas contains of, can be statistically described by headway distribution and number variance. This allows us to check the any particular implementation of the Metropolis algorithm because the analytical predictions of these characteristics are known. By choosing the right potential (the way particles interact with each other) and temperature we can make the particles behave the same way as vehicles on a road.

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Mechanical and ultrasound testing of human skin in vivo

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Abstract

The skin has a nonlinear viscoelastic behaviour, that is it has both the properties of a viscous fluid and elastic properties of a solid. It is anisotropic in its plane but may be considered orthotropic for certain areas of the body. Besides, it's an incompressible material. In the simplest case, we consider that the behaviour is elastic, it means that relations between the stresses and strains are linear. To take into account the viscoelastic nature which is often important into the skin, it will identify other parameters. The propagation of acoustic waves is directly related to the properties of a material. It is therefore interesting to study these waves to characterize the skin. The study improves the following aspects : The experiment based on guided ultrasonic wave propagation along paths of human body surface, the models for modelling the mechanical behaviour of viscoelastic materials and the simulations of hysteresis behavior.

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Nonlinear Signal Processing for Modern Ultrasonic Imaging : Applications to Material Diagnostics

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Abstract

A systemic approach of modern ultrasonic imaging of material complexity has been described and tested experimentally on the nonlinear elastic wave spectroscopy of a human tooth and complex shape composites from the aeronautic industry. The associate symmetrized nonlinear signal processing using time reversal invariance, reciprocity, and optimized excitations such as pulse-inverted, chirp-coded or bi-solitonic signals is described with the concept of symmetry analysis using Lie groups theoretical framework. Experiments are conducted on complex samples open new perspectives in the context of Nondestructive Testing (NDT) and medical imaging of complex media such as a human tooth, the skin or the brain.

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Parking and the visual perception of space

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Abstract

Using measured data we demonstrate that the statistical properties of the distances between parked cars and the distances between birds perching on a power line are identical. We show that this observation is easily explained by the fact that birds and human use the same mechanism of distance estimation. We give a simple mathematical model of this phenomenon.

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Model based clustering via the distribution mixtures

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Abstract

The finite distribution mixtures present a wide class of probability distributions. Apart from the obvious application as the distribution estimator of the population with more than one underlying independent phenomena, the mixtures are successfully applied in the model based clustering. If we constraint the members of the mixture to arise from one specific family or type of parametric distributions, each cluster would refer to one component of the mixture. The membership of the observed sample to a cluster is given simply as the maximum probability on the components of the mixture, i.e. by the Mahalanobis distance, and weighted by the weights of the mixture. This approach is feasible even for overlapping clusters and strongly uneven numbers of the members of the clusters, where standard methods of cluster analysis fall short. We provide with an introduction to the distribution mixtures, focusing on the problem of fitting the mixture to observed sample using the maximum likelihood approach and the EM algorithm, as well as the assessment of the optimal number of components.

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Spectral properties of non-gaussian random matrices

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Abstract

The main topic of this article is spectral analysis of random matrices. It is well known that distribution of normalized eigenvalues of general and real gaussian matrices is described by the Girko's circle law, i.e. eigenvalues of matrix lie inside of unit circle centered to origin of the complex plain. If the random matrix is symmetrical the distribution of eigenvalues is described by Wigner's semicircle law. Furthermore, the so-called spacing distribution is investigated. This quantity is random and its distribution is described by Izrailev's formula. Generalizations of these laws for non-gaussian matrices are introduced. Numerical tests (implemented in MATLAB) have shown that properties of eigenvalues of real non-gaussian matrices are influenced by variance of elements of matrix only and they are independent of their distribution. The mentioned tests were executed for matrices with elements chosen from uniform, Poissonian and gamma distribution. Moreover, the hypothesis about generalized Girko's circular law for random matrices with arbitrary distribution is presented.

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Backward Stochastic Differential Equations and their application to stochastic control.

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Abstract

In this article we introduce the concept of Backward Stochastic Differential Equations (BSDE) and provide fundamental theorems of existence and uniqueness of the solution. We also show by example its connection to financial mathematics. Further, we introduce a general problem of stochastic control and show how it can be solved by using the BSDE theory via generalized Hamiltonian of the system. At the end, we mention some possible generalizations by considering fractional Brownian motion as a noise source.

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Applied proxemics

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Abstract

Distances kept among people in public transport systems are essential for its functioning; it is due to the fact that the area (for example, of a train) is limited by the size of means of transport, and the proxemics determine density of people. The smaller the distances, the higher the density; the higher the density, the more the people transported. Importance of proxemics increases these days; favourable sitting order, distances kept among individuals, psychological behaviour, and many others are subject of recent sociological studies. Main aim of this study is to investigate and examine the distances kept in public transport system, as well as investigate the places where the data were collected. In order to examine these distances, an experiment was made. The experiment took place at one of the traffic junctions in Prague, the central train station. The video records were made, and the required data were measured (or counted). The results of our research show that there might be connection between measured distances for humans and distances measured for cars, presented by Mr. Milan Krbálek. Nevertheless, further research of this subject is required.

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Localization of geodesic curves on surfaces

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Abstract

Geodesic curves play an important role in the computer simulations. A solution of geodesic equations and a shortest path in the graph theory is described. Further, we demonstrate and compare an existing algorithms for computation the geodesics on surfaces i.e. Newton-Raphson method and Dijkstra's algorithm. We propose a few improvements involving triangulation of surface. Geodesic curves may find application in failure crack detection in acoustic emission. By means of geodesic curves we try to localize AE source on topological surfaces. We deal with cylinders, spheres, cones and their compositions with various types of intersections. The solution of the intersections can be complicated and the main task is finding geodesics, which go through points of the intersections. Hence, we discuss problems with testing solid composed of two cones.

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