SPMS 2020

Thursday 17 September 2020 - Monday 21 September 2020

The 11th International Conference

SPMS 2020

GAMS

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

Stochastic and Physical Monitoring Systems

17.9. - 21.9.2020

Book of Abstracts

Dear Friends and Colleagues,
it is our pleasure to welcome you to the 11^{th} International Conference
STOCHASTIC & PHYSICAL MONITORING SYSTEMS.

The SPMS 2020 conference is held 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. 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 (GAMS), Department of Mathematics, FNSPE Czech Technical University in Prague and this year's venue is for the first time Chlum u Třeboně and has many sports facilities.

Local Organizing Committee:
Václav Kůs (Chair),
Jiří Franc,
Jana Vacková,
Petr Bouř.

Scientific and Program Committee:
Milan Krbálek,
Tomáš Hobza,
Václav Kůs,
Jiří Franc.

We gratefully acknowledge the institutional support provided by the funds of specific research, namely by the SGS grant SVK26/20/F4.

`The Organizers`

Contents

Stochastic Monitoring Systems / 6

Variational Bayes for Blind Image Deconvolution

Author: Antonie Brožová[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: brozoant@fjfi.cvut.cz

The aim of blind image deconvolution is to estimate latent image and blur from observed blurred image. This problem is higly ill-posed. One of the approches used for blind image deconvolution is Variational Bayes (VB). Relations between data, blur and latent image are described using probabilistic model and posterior probabilities are approximated via VB inference. Solution can be obtained iteratively by minimizing Kullback-Leibler divergence of approximation to correct solution. This presentation will focus on optimization using stochastic gradient descent with reparameterization trick for model assuming image smoothness.

Traffic and Agent Monitoring Systems / 3

Cellular or Continuous?

Authors: Marek Bukáček[1] ; Jana Vacková[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: marek.bukacek@seznam.cz

The history of pedestrian modelling is close to 10 years anniversary. Within this period, two models have been developed aside of experimental research - cellular and continuous. Even the same motivation and microscopic, rule based approach were applied, there are many different features - benefits and drawbacks on both side. The aim of this article is to revisit the development process, discuss differences and show the most important results.

Acoustic Emission and Material Diagnostics / 15

Investigation of mechanical properties of orthopaedic titanium alloys by acoustic emission monitoring

Author: Milan Chlada[1]

Co-author: Zdeněk Převorovský [1]

[1] *Institute of Thermomechanics CAS, Prague, Czech Republic,*

Corresponding Author: chlada@it.cas.cz

Acoustic Emission (AE) method, widely used for non-destructive evaluation and material characterization, is very beneficial for monitoring of highly dynamic damage processes. Computational power of contemporary regular hardware enables to test the new approaches in this field as it could not be done before without the capability of continuous signal recording and analysis. Modern portable measuring devices as USB oscilloscopes with data streaming feature can be flexibly controlled by scripts tailored for particular experiment. AE activity can be thereby evaluated on-line in more detail by specially designed parameters. The running experiment can be controlled by actual state of material damage as well. Such approach is demonstrated during the test of titanium alloys for orthopaedic implants. The AE method provided comprehensive data to identify the initial stages of

damage and crack propagation in the stressed specimen. Small AE system based on streaming oscilloscopes proved well for continuous monitoring of appearance and propagation of cracks during static loading of Ti-Mo-Si alloys. This approach enabled to verify the influence of molybdenum and silicone concentrations in alloys used for orthopaedic prosthesis.

Acoustic Emission and Material Diagnostics / 2

Structure of hysteretic material evaluated through Preisach-Mayergoyz space

Author: Erik Dolejš[1]

Co-author: Václav Kůs [1]

[1] *Department of Mathematics, FNSPE, Czech Technical University in Prague*

Corresponding Author: dolejeri@fjfi.cvut.cz

This paper focuses on the application of Preisach-Mayergoyz (PM) model applied to the evaluation of the elastic properties of the material. In the first section, there are explained basic vital terms, such as hysteresis, and it's properties, optimization algorithms, suitable probability density functions and ϕ-divergences. This knowledge is implemented in the presented program designed to identify PM space. In the next section, there are proposed two descriptions of PM space of hysterons based on kernel density estimation. Formed on this description, we propose a new index of elasticity, which describes the ability of materials to absorb mechanical deformation. In the end, experimentally measured data of test of steel dampers used for protection against earthquake are processed, and the proposed index of elasticity is evaluated.

Acoustic Emission and Material Diagnostics / 18

Acoustic Emission Signals Classification

Authors: Zuzana Dvořáková[1] ; Václav Kůs[1] ; Zdeněk Převorovský[2]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

[2] *Institute of Thermomechanics of the Czech Academy of Sciences*

Corresponding Author: zuzana.dvorakova@fjfi.cvut.cz

Acoustic emission (AE) method is one of non-destructive methods in defectoscopy and enables to reveal the damage in materials or construction before fatal destruction of the construction. In this method two parts are crucial. First we have to find parameters which are able to distinguish signals cased by damage in material and all others unimportant acoustic emission signals. And next we have to apply a suitable classification method in order to create cluster in feature space, where one cluster contains signals coming from the one type of AE. In both steps we apply phi-divergence. First we apply phi-divergence between normed spectra in order to obtain suitable parameter for classification. Phi-divergence we use also in the classification method, we suggested so-called Divergence Decision Tree, where phi-divergence is as decision criterion. We tested the suggested parameter and method on laboratory measured data.

Stochastic Monitoring Systems / 10

Solving the eikonal equation on GPU

Author: Matouš Fencl[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: fenclmat@fjfi.cvut.cz

The eikonal equation is discretized with diferent space steps. Solution of eikonal equation is found in a form of the signed distance function. Further more, the Fast Sweeping Method is implemented into the TNL library via C++ programming language on CPU and via nVidia CUDA toolkid on GPU. Results are presented in form figures, tables of experimental order of convergence (EOC) and tables of computation time. At the end the Fast Sweeping Method is used to examine the wildfire problem.

Traffic and Agent Monitoring Systems / 4

Estimates of Similarity Dimension via Diffusion over Compact Subsets of Regular Grids

Author: František Gašpar[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: gaspafra@fjfi.cvut.cz

The diffusion can be studied in d-dimensional space where d can also be non-integer value. The solution of the diffusion equation for such spaces is known and serves as basis of presented time and diffusion coefficient invariant dimension estimate. Using compact subsets of regular grids as finite fractal sets models discrete diffusion model is introduced. Results of diffusion simulations on the model of Sierpisnky Gasket are presented and used to test the applicability of the derived dimension estimate. The contribution is complemented by a discussion of the implementation.

Traffic and Agent Monitoring Systems / 11

Gap acceptance for vehicles at an unsignalized T-intersection

Author: Nikola Groverová[1]

Co-author: Milan Krbálek [1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: grovenik@fjfi.cvut.cz

We introduce the gap acceptance theory originated from vehicular traffic engineering while dealing with computations of the capacity of unsignalized intersections. There are certain interesting phenomena that have been observed for this specific traffic situation, such as the linear trend for the mean critical gap accepted by a certain number of vehicles. Using empirical data gauged at intersections in Munich and Dresden, we will demonstrate how probability functions, used recently in vehicular headway modelling, are suitable for the probabilistic predictions of critical gaps and intersection capacity. We will also outline the analytical approach to gap acceptance theory, that supports the observed phenomena.

Stochastic Monitoring Systems / 16

Domination relations between distances on probability spaces, their properties and implications to L_1 consistency of MDE

Authors: Jitka Hrabáková[1] ; Václav Kůs[2]

[1] *Department of Applied Mathematics, FIT Czech Technical University in Prague*

[2] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: jitka.hrabakova@fit.cvut.cz

This contribution deals with domination relations between distances on probability spaces. Implications of domination relation between Kolmogorov and total variation distance to L_1 consistency of Kolmogorov MDE is known. We will extend this result to another distances (Lévy, discrepancy, bounded divergences), for this purpose we focus especially on relation of particular distances to total variation distance and Kolmogorov distance, which enable us to prove L_1 consistency of respective minimum distance estimators using formerly published results. Various assumptions leading to consistency in L_1 norm and expected L_1 norm of particular MDE are studied and compared. Further, generalization of domination relation, so called asymptotic domination relation is introduced and relation to original domination relation is studied. We will show that asymptotic domination relation suffices to ensure L_1 consistency of MDE, thus we prove the same results for Kolmogorov and other distances under general assumptions.

Machine Learning and Data Processing / 9

Deep Learning in CERN and ESA: Report On Remote Internshipss

Author: Kristina Jarůšková[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: jaruskri@fjfi.cvut.cz

Introduction of the Openlab group at CERN and CAVES & Pangaea group at the European Space Agency (ESA) and report on remote internships in both of these groups. Apart from many other tasks, CERN openlab group works on developing a generative adversarial network to replace the Monte Carlo generators for event simulations for the future HL-LHC. CAVES & Pangaea group at ESA wants to equip astronauts with a device for in situ identification of minerals based on their spectra.

Acoustic Emission and Material Diagnostics / 8

Blind Extraction of Moving Source from Linear Mixture

Author: Václav Kautský[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: kautsvac@fjfi.cvut.cz

This paper focuses on extraction of a moving source of interest (SOI) form a linear mixture. The rest of the mixture is called the background. The parameterization of the mixture is designed according to a well-known independent component analysis (ICA) model, although, ICA deals only with static mixtures. Thus, the extension to dynamic sources is completely novel. The model dynamics is described in two ways: moving SOI with static background, and static SOI with moving background. In

the experimental part, novel approaches are applied to real speech sources, and compared to state-of-the-art algorithms. The asymptotical performance, expressed in terms of Cramér-Rao Lower Bound on separation accuracy, shows huge potential of proposed methods.

Stochastic Monitoring Systems / 12

Comparison of mean vs median performance of selected stock portfolios

Author: Tomáš Košlab[1]

Co-author: Přemysl Bejda

[1] *FinMason Europe, Prague*

Corresponding Author: koslatom@fjfi.cvut.cz

It has been documented (see e.g. article by Bessembinder) that there is positive skewness in the distribution of individual stock returns. Based on this hypothesis we present a study in which mean versus median performance of stock portfolios is compared. Unlike other works, the aim of this study is not to create a robust portfolio, but rather to investigate the amount of skewness one can see when investigating different types of stocks. For this reason the sets that are worked with are chosen in such manner that they contain stocks which are somehow similar (e.g. US technology firms). The effect of different choice of stocks as well as other changes in the setup of the experiment are discussed and visualized.

Stochastic Monitoring Systems / 7

Robust Estimation in Poisson Regression Models

Author: Jana Novotná[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: novotj88@fjfi.cvut.cz

The aim of the contribution is to present a new robust estimator for Poisson regression models – the modified median estimator. The definition of the modified median estimator was based on the median estimator, so we will first get acquainted with this estimator and then explain the transition to the modified median estimator. In the next part, we will describe simulation studies examining the behavior of the modified median estimator when estimating from contaminated data. Thanks to the results of the simulations, it will be clear when it is advantageous to use the modified median estimator and what is its main advantage over the median estimator. Finally, the results of the current research of the modified median estimator will be presented, specifically we will introduce the asymptotic distribution of this estimator.

Machine Learning and Data Processing / 5

Field crops classification using Sentinel-2 satellite image data

Author: Adam Novotný[1]

[1] *Department of Mathematics, FNSPE Czech Technical University in Prague*

Corresponding Author: novotad2@fjfi.cvut.cz

Sentinel-2 mission, developed and operated by ESA, is designed to provide high-resolution image data over land and coastal waters, which are further used for a multitude of applications, such as agricultural monitoring. Acquired data by the Sentinel-2 satellite are publicly available under the Copernicus Programme and can be accessed straightforwardly. In addition, we are provided with annotated maps of agricultural fields, which can be used as ground truth data. These maps include the location and additional specification of fields and crops grown on the field.

In this paper, we are interested in field crop classification within the specified region. Aforementioned Sentinel-2 satellite image data and field labels are therefore combined to provide a dataset. This dataset can be then utilized by the classifier. For this cause, convolutional neural networks (CNNs) are used, as they have shown outstanding results of image classification over the past years.

Stochastic Monitoring Systems / 1

Real Options Valuation: A Dynamic Programming Approach

Author: Filip Rolenec[1]

[1] *Department of Mathematics, FNSPE, Czech Technical University in Prague*

Corresponding Author: rolenfil@fjfi.cvut.cz

Investment opportunities are currently valued via metrics and algorithms formed by the economical theory. The majority of investors still values projects with the *net present value* (NPV) method, which takes into account the time value of money and gives solid results for simple projects with minimal requirements on mathematical skills. More complicated projects, which are in this thesis thought of as projects with a substantial degree of inner uncertainty and with an existence of further managerial decisions, can be valued by the *real options analysis* (ROA). This method comes from an imperfect analogy to financial option valuation and it recognizes the value of the ability to change the course of a given project.

My thesis presents a new valuation framework for projects, which are understood as stochastic decision problems. This framework incorporates the NPV and ROA methods, relaxes their assumptions and allows for decades of research in the field of *stochastic decision theory* (SDT) to be used. The main contributions of the new framework are: ability to incorporate multiple sources of uncertainty, usage of any distribution for uncertainty modeling, ability to conveniently incorporate Bayesian learning, ability to model user's approach to risk and ability to model any type and number of managerial actions.

The new framework significantly expands the class of projects that can be reasonably valued and can be understood as a unification of project valuation in business management.

Machine Learning and Data Processing / 13

Mask R-CNN Robust method for Object Detection and Segmentation

Authors: Dominik Vít[1] ; Lukas Tryner[1]

[1] *DataSentics, Prague*

Corresponding Authors: dominik.vit@gmail.com, lukas.tryner@datasentics.com

Many real-world computer vision tasks require not only object detection but rather instance segmentation, which holds information of object shape and location within an image. Thanks to deep learning, there are methods which robustly and efficiently detect objects in the image while simultaneously generating a high-quality segmentation mask for each instance. Mask Region-based Convolutional Neural Network (Mask R-CNN) is one of these deep learning methods, which has been a state-of-art framework for Object Detection and Segmentation since 2017. We show how it can be implemented for detecting out-of-stock products in store shelves, detecting face features for plastic surgery predictions, beer quality inspection or for assisting visually impaired people with shopping.

Acoustic Emission and Material Diagnostics / 17

Dispersion curves and their measurement

Authors: Radovan Zeman[1] ; Jan Kober[1]

[1] *Institute of Thermomechanics of the Czech Academy of Sciences*

Corresponding Author: zemanra5@fjfi.cvut.cz

In dispersive media wave propagation characteristics are function of frequency and dispersion curves determination is useful to process signals with waveform distortion or estimate parameters. In particular, Lamb waves, which are propagating in thin plates, are typical representatives of dispersive waves. The aim is determination of dispersion curves corresponding to real solutions of Rayleigh-Lamb equations. This presentation reports dispersion curves determination by means of Fourier transform. Experimental or numerical procedure is suggested to obtain suitable wave propagation representation and two-dimensional Fourier transform is carried to go to frequency-wavenumber domain, where dispersion curve is distinguishable. Image processing methods, such as equalization, thresholding, are used to extract dispersion curve and parameters (i.e. propagation velocities and thickness) are estimated.