StatMod2021: Statistical Modeling with Applications

Laboratory of Mathematics Raphaël Salem, University of Rouen-Normandy, France
"Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania
&
Laboratory of Mathematics Nicolas Oresme, University of Caen-Normandy, France

December 3–4, 2021

StatMod2021.org

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Topics

Stochastic processes

Markov and (hidden) semi–Markov processes

Mixture models

Statistics for dependent random variables

Entropy and divergence measures

Statistical methods and applications

Goodness–of–fit tests

Mathematical reliability

Functional data analysis

Stochastic ordering

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Nicolas VERGNE (Univ. of Rouen–Normandy, France)

ABSTRACTS

Chafiàa AYHAR (Univ. Dr. Moulay Tahar of Saïda, Algeria)

Numerical solutions of Markov renewal equations for continuous-time semi-Markov processes

joint work with Fatiha MOKHTARI, Saâdia RAHMANI (Univ. Dr. Moulay Tahar of Saïda, Algeria), Vlad Stefan BARBU (Univ. of Rouen-Normandy, France)

Abstract: For a given homogeneous semi-Markov process (SMP) with piecewise continuous semi-Markov kernel, the transition and the probability functions are obtained by Markov renewal equations. Janssen and Manca (2001) and Corradi et al. [2] have solved numerically this system of integral equations using general quadrature formulas. We present in this work the methods in Wu et al. [1] and Corradi et al. [2] to solve continuous-time semi-Markov processes by algorithms from discrete-time case, based on the fact that the transition function of a SMP can be the approximated by the corresponding one of a discrete-time semi-Markov process. By using this previous method, we present some simulations of transition probability approximation of continuous-time semi-Markov processes.

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[2] Gianfranco Corradi, Jacques Janssen, Raimondo Manca (2004). Numerical treatment of homogeneous semi-Markov processes in transient case-a straightforward approach - *Methodology and Computing in Applied Probability*, 6, 233-246

Lucian BEZNEA (Univ. of Bucharest & "Simion Stoilow" Institute of Mathematics of the Romanian Academy, Romania)

Scaling property for fragmentation processes related to avalanches

joint work with Madalina DEACONU (INRIA Nancy, France) and Oana LUPAŞCU-STAMATE ("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Abstract: We emphasize a scaling property for the continuous time fragmentation processes related to a stochastic model for the fragmentation phase of an avalanche. We present numerical results that confirm the validity of the scaling property for our model, based on the appropriate stochastic differential equation of fragmentation and on a fractal property of the solution.

Bogdan Corneliu BIOLAN (Univ. of Bucharest, Romania)

Teaching and learning mathematical modelling: a review on the state of the art of recent approaches

Abstract: The analysis of teaching and learning mathematical modelling represents a relevant topic in the field of mathematics. This paper aims to review the state of the art on the recent research studies regarding this subject. We investigate the development of studies focusing on cognitive aspects of mathematical modelling learning techniques, such as modelling abilities and skills, namely, modelling competencies. The analysis of recent results highlights the prevalence of case study approaches and cognitively based methods comparative to quantitative or affect-related approaches.

Badreddine BOUMARAF (Univ. of Souk-Ahras, Algeria)

TBA

Abstract: TBA

Luigi-Ionuț CATANĂ (Univ. of Bucharest, Romania)

Improvements of a theorem regarding the stochastic ordering of log-scale-location distributions

joint work with Vasile PREDA ("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics & "Costin C. Kiritescu" National Institute of Economic Research & Univ. of Bucharest, Romania)

Abstract: In this presentation we generalize a theorem from Preda and Catana (2021). This theorem refers to the stochastic ordering of log-scale-location distributions.

Ciprian Mihai CEAUSESCU (Univ. of Bucharest, Romania)

Brain tumor segmentation using Transfer Learning

joint work with Bogdan ALEXE ("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics & Univ. of Bucharest, Romania) and Denis ENACHESCU ("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Abstract: In the analysis of medical images, people are often interested only in certain parts of the input images. These parts are often called targets or foregrounds, and they generally correspond to specific, unique regions of the image. In order to identify and analyze the target, these relevant regions need to be separated and extracted. Image segmentation refers to the technique and process of dividing an image into characteristic regions and extracting objects of interest.

In the current work, we address the task of brain tumor segmentation in medical images. We investigate the problem of leveraging information between two datasets by transfer

learning knowledge specific to one dataset to the other. We use as datasets the BRATS 2020 (Center for Biomedical Image Computing) and BrainMetShare (Stanford) datasets and employ a state-of-the-art convolutional neural network U-Net. We present results for various settings of transfer learning the knowledge from one dataset to the other.

Gaëlle CHAGNY (Univ. of Rouen–Normandy & CNRS, France)

Adaptive estimation of the nonparametric component under a two-class mixture model

joint work with Antoine CHANNAROND (Univ. of Rouen–Normandy, France), Van Hà HOANG (Vietnam National University, Vietnam), Angelina ROCHE (Univ. Paris Dauphine, France)

Abstract: We consider a two-class mixture model, where the density of one of the components is known (equal to the uniform density on the interval [0; 1]). This problem appears in many statistical settings, robust estimation and multiple testing among others. We address the issue of the nonparametric adaptive estimation of the unknown probability density of the second component. We propose a randomly weighted kernel estimator with a fully data-driven bandwidth selection method, in the spirit of Goldenshluger and Lepski (2011). Its definition involves empirical counterparts both for the mixture density and the mixing proportion: preliminary estimators for these quantities are also proposed. An oracle-type inequality for the pointwise quadratic risk is derived as well as convergence rates over Hölder smoothness classes. The theoretical results are illustrated by numerical simulations.

Simona COJOCEA (Univ. of Bucharest, Romania)

Approximating Kolmogorov moments using Bernstein polynomials

Abstract: Traditionally, we gather information about a random variable by studying its moments. But sometimes that information doesn't suffice, or can't be extracted because the moments don't exist, as it happens in the case of the Cauchy distribution, for example. That particular situation motivates us to find alternative ways to study a random variable, one of them being the use of a generalization of the regular mean, called the Kolmogorov mean. As it is a transformation applied over the regular mean of a function of the random variable, it always exists, at least for a particular g function. This can be very helpful, but a new problem arises: how to estimate those moments, as their exact computation may be difficult at times. One solution we provide is the use of the Bernestein polynomials, which assure a good convergence of the results. We also give some practical examples where using this approach to approximate Kolmogorov moments is particularly useful.

Guglielmo D'AMICO (Univ. "G. d'Annunzio" of Chieti-Pescara, Italy)

Sequential Interval Reliability for semi-Markov repairable systems in discrete time

joint work with Vlad Stefan BARBU and Thomas GKELSINIS (Univ. of Rouen–

Normandy, France)

Abstract: This talk will cover discrete-time semi-Markov processes in homogeneous case. In the beginning, we present the general problem of the reliability of a repairable system. We discuss relevant performability indicators such as the availability, reliability and maintainability functions. Furthermore, a new reliability measure, named Sequential Interval Reliability. This measure is the probability that the system is working in a given sequence of non-overlapping time intervals. Many reliability measures are particular cases of this new measure that we propose; this is the case for the interval reliability, the reliability function and the availability function. A recurrent-type formula is established in the transient case and an asymptotic result determines its limiting behavior. The results are illustrated using some numerical examples which illustrate the possible application of the measures to real systems.

Jun Tao DUAN (Georgia Institute of Technology, USA)

A CLT with dependencies and applications to sketching

joint work with Ionel POPESCU (Univ. of Bucharest & "Simion Stoilow" Institute of Mathematics of the Romanian Academy, Romania)

Abstract: We provide a CLT for sums of strongly dependent random variables and show that we can use it to give a statistical test for the angle between projected vectors used in sketching, a dimension reduction technique for linear regression.

Mohamed EL MACHKOURI (Univ. of Rouen–Normandy, France)

On the Nadaraya-Watson estimator for spatial dependent observations

joint work with Xiequan FAN (Tianjin Univ., China) and Lucas READING (Univ. of Rouen–Normandy, France)

Abstract: In this work, we investigate the asymptotic normality of the classical Nadaraya–Watson kernel regression estimator for data collected on a finite region of the lattice Z^d , where d is a positive integer. The results are stated for strongly mixing random fields in the sense of Rosenblatt (1956) and for weakly dependent random fields in the sense of Wu (2005). Only minimal conditions on the bandwidth parameter and simple conditions on the dependence structure of the data are assumed.

Mitra FOULADIRAD (Univ. Aix Marseille & École Centrale de Marseille, France)

Conditional imperfect maintenance of a deterioration process

joint work with Franck CORSET (Univ. Grenoble Alpes, France) and Christian PAROISSIN (Univ. of Pau and the Adour Region, France)

Abstract: A gamma process for degradation modeling of a system is considered. The system is periodically inspected. At each inspection, a decision is taken with respect to the level of the degradation process. Perfect corrective maintenance and imperfect preventive maintenance are considered. The imperfect action is modelled by an arithmetic reduction of degradation, i.e. the improvement is proportional to the degradation level at the inspection time. The stationary distribution of the underlying Markov renewal process is calculated and the maintenance cost is derived and optimized.

Alex KARAGRIGORIOU (Univ. of the Aegean, Greece)

An exponential characterization with applications in tests of fit

joint work with Ioannis MAVROGIANNIS (Univ. of the Aegean, Greece), Georgia PAPASOTIRIOU and Ilia VONTA (National Technical Univ. of Athens, Greece)

Abstract: This work is filling up the gap in the literature regarding the verification of the log-concavity property which is a widely studied topic due to the fact that it provides desirable estimating properties. At the same time, it is vital in reliability, engineering and stochastic modeling for distinguishing between an exponential, a light-tailed and a heavy tailed distribution. In this work we propose an exponentiality test of fit to be used for distinguishing between exponential and log-convex or long-concave distributions. The proposed test statistic is based on the conspiracy and catastrophe principles and establishes a characterization for the exponential distribution. The details of the formulation of the test are provided, an extended simulated study which shows the performance of the proposed test statistic is given, and some concluding remarks are stated.

Amor KEZIOU (Univ. of Reims, France)

Robust empirical likelihood

joint work with **Aida TOMA** (Bucharest Univ. of Economic Studies & "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Abstract: We introduce robust version of the empirical likelihood estimator for semiparametric moment condition models. The new estimator is obtained by minimizing the modified Kullback-Leibler divergence, in its dual form, using truncated orthogonality functions.

Andreas MAKRIDES (Univ. of Uclan, Cyprus & Univ. of the Aegean, Greece)

On some aspects of reliability inference with semi-Markov processes

Abstract: Semi-Markov processes are typical tools for modeling multi state systems by allowing several distributions for sojourn times. In this work, the sojourn times are considered to follow the Kumaraswamy distribution with two shape parameters which belongs to a general class of distributions with the advantage that is closed under minima.

We provide estimators for the parameters of interest and we evaluate our methodology using an exhaustive simulation study.

Bojana MILOŠEVIĆ (Univ. of Belgrade, Serbia)

Goodness-of-fit tests for censored data: a look at the past, present and future research

joint work with Marija CUPARIĆ (Univ. of Belgrade, Serbia)

Abstract: In survival analysis, sample is often limited due to some censoring mechanism. Although the first goodness-of-fit tests for this kind of data have been proposed in the middle of 20th century, the interest for this topic has increased recently. Here we provide an overview of existing methodologies. We illustrate their pros and cons on several time-honoured and recent exponentiality tests. The significant part of the talk is dedicated to presentation of working results and directions for future research.

References

[1] M. Cuparić, B. Milošević. New characterization based exponentiality tests for randomly censored data. *Test*, 2021. doi:10.1007/s11749-021-00787-7

[2] M. Cuparić. Asymptotic properties of inverse probability of censored weighted U-empirical process for right-censored data with applications. *Statistics*, 2021. doi:10.1080/02331888.2021.1998054

Hasan MISAII (Univ. of Technology of Troyes, France & Univ. of Tehran, Iran)

Optimal shock-based maintenance policy for a system in a dynamic environment

joint work with Firoozeh HAGHIGHI (Univ. of Tehran, Iran) and Mitra FOULADIRAD (Univ. Aix Marseille & École Centrale de Marseille, France)

Abstract: In this paper, we consider a single-unit system operating in a dynamic environment subject to shocks. Shocks are non-lethal and only affect the system and their arrivals is modelled is by a counting process: homogeneous and non-homogeneous Poisson process. The environmental conditions impacting the shock effects are modelled through a multiplicative failure rate model.

Two policies considering corrective maintenance and shock-based preventive maintenance are considered. In the first policy, the system is replaced as good as new either at failure or after a predetermined number of shocks, whichever comes first. The second policy extends the first one by considering an imperfect preventive repair at each inspection time. The inspection times are periodic and the inter-inspection interval is considered as a decision variable.

The proposed policies are optimized according to long-run cost rate criteria. Numerical examples illustrate the applicability and efficiency of the proposed policies.

Rochdi NOUADRI (Univ. of Badji Mokhtar of Annaba, Algeria)

Different estimation methods for Nadarajah distribution

joint work with Nacira SEDDIK-AMEUR (Univ. of Badji Mokhtar of Annaba, Algeria)

Abstract: Nadarajah distribution is a very interesting model in the sense that it can be considered as a good alternative for gamma, Weibull and exponentiated exponential distributions and this distribution can have an increasing hazard rate when the probability density function is monotonically decreasing and this fact cannot be realised for the other models. This work deals with the estimation of Nadarajah distribution parameters by different methods. As the explicit forms of the maximum likelihood estimators (MLE) cannot be derived, we propose the use of several methods such as method of the maximum product of spacing (MPS), method of Cramer-von-Mises (CM), method of Anderson-Darling (AD), method of Right-tail Anderson-Darling (RAD), Left-tail Anderson-Darling (LAD) and the method of Kolmogorov-Smirnov (K-S) to determinate the parameter estimators. An important simulation study is given to compare between the method performances and real data are used for illustration.

Christina PARPOULA (Panteion Univ. of Social and Political Sciences, Greece)

Optimal multiple change-point detection and inference

joint work with Alex KARAGRIGORIOU (Univ. of the Aegean, Greece)

Abstract: Change-point detection is the task of finding abrupt changes in the underlying model of a signal or time series. This work addresses the problem of "a posteriori" optimal change-point detection and inference and the main goal consists in recovering the configuration of change points using the whole observed series. Under this framework, a recursive optimization algorithm is developed for selecting the optimal number of segments subject to the constraint of a minimum segment length, given a stream of process data. This procedure provides an empirical reasonable compromise for fine tuning these two parameters. It therefore addresses a wide class of real-life contexts and problems where the identification of optimal level shifts in a time series is the main goal. Extensive simulation results are presented and some concluding remarks are made.

Valentin PATILEA (ENSAI Rennes & CREST, France)

Learning the regularity of curves in functional data analysis and applications

joint work with Nicolas KLUTCHNIKOFF (Univ. Rennes 2, France) and Steven GOLOVKINE (CREST, France)

Abstract: Combining information both within and across trajectories, we propose simple estimators for the local regularity of the trajectories of a stochastic process. Independent trajectories are measured with errors at randomly sampled time points. Non-asymptotic

bounds for the concentration of the estimator are derived. Given the estimate of the local regularity, we build a nearly optimal local polynomial smoother from the curves from a new, possibly very large sample of noisy trajectories. We derive non-asymptotic pointwise risk bounds uniformly over the new set of curves. As another application, we build minimax optimal mean and covariance functions estimators. Our estimators perform well in simulations. Real data sets illustrate the effectiveness of the new approaches.

Nathalie PEYRARD (INRAE Toulouse, France)

A hidden semi-Markov model for inferring the structure of migratory bird flyway networks

joint work with Marie-Josée CROS, Régis SABBADIN, Ronan TRÉPOSE (INRAE Toulouse, France), Sam NICOL (CSIRO Land and Water, Australia)

Abstract: Measuring the connectivity of birds' stopovers on the migratory paths is challenging due to the wide geographic areas and vast numbers of individuals involved. A complementary approach to tracking individuals is to infer connectivity from count data at known aggregation sites. We model here a migratory flyway as a weighted network and we present a Hidden Semi Markov Model of the hidden birds trajectories and the observed counts. Exact application of estimation algorithms based on the likelihood for inferring the model parameters is not possible for even a small number of sites due to the high dimension of the hidden state. To overcome this, we derived two algorithms for approximated estimation: Monte Carlo Expectation-Maximisation and Approximate Bayesian Computation. We compare the quality of estimation of these two approaches on synthetic data and on a case study of a migratory shorebird in the East Asian-Australasian flyway.

Cristian PREDA (Univ. of Lille, France & "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Descriptive statistics for categorical functional data

joint work with Quentin GRIMONPREZ (Diagrams Technologies, France), Vincent VANDEWALLE (Univ. of Lille, France)

Abstract: Data represented by paths of a continuous-time stochastic jump process will be considered in the framework of functional data analysis. Dimension reduction, clustering and regression will be illustrated throughout the cfda R package on simulation and real data applications.

Sorina-Cezarina SFETCU (Univ. of Bucharest, Romania)

Inaccuracy measures using copulas

joint work with Răzvan-Cornel SFETCU (Univ. of Bucharest, Romania) and Vasile PREDA

("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics & "Costin C. Kiritescu" National Institute of Economic Research & Univ. of Bucharest, Romania)

Abstract: We introduce new innacuracy measures and study some properties of them. Among results, we find some bounds for these inaccuracy measures and prove that the triangle inequality is valid.

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[2] N.I. Fisher, Copulas, In: S. Kotz, C.B. Read, D.I. Banks (Eds.), Encyclopedia of Statistical Sciences, update Vol. 1, Wiley, New York, 1997.

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[4] R.B. Nelsen, An Introduction to Copulas, Springer-Verlag, New York, 2007.

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Radu STOICA (Univ. of Lorraine, France)

Markov modelling for pattern detection and characterization

Abstract: Markov probabilistic modelling allows the description of complex patterns via 'simple local' interactions. Their application to pattern statistical characterization or detection (whenever these are hidden in the observed data) allows the implementation of stochastic algorithms and statistical inference procedures, that furnish robust and interpretable results. This talk presents the main ideas of these mathematical tools, together with direct applications from astronomy, geology and social networks.

Florentina SUTER (Univ. of Bucharest & "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Generalized exponential distributions with applications in systems reliability

Abstract: Exponential distribution is a very important distribution in modelling lifetime data and various generalizations of it have applications in systems reliability. In this presentation we will review some models of this type and discuss their properties.

Romică TRANDAFIR (Technical Univ. of Civil Engineering of Bucharest, Romania)

Estimations of Tsallis entropy for lomax function distribution based on record

joint work with Mihaela PĂUN, Ioana DĂNILĂ, Aurelia CASARU (Univ. of Bucharest,

Romania)

Abstract: In this paper the authors propose estimators for both parameters of the Lomax distribution using the Tsallis entropy based on upper record values. The MLE and Bayesian estimation techniques are used to determine such estimators in the case of non-informative prior and in the case of informative prior considering squared error loss function, linear exponential loss function and precautionary loss function. A numerical study is presented where the Bayesian estimators are discussed using non-informative and informative priors under the previous three loss function and different width intervals under non-informative prior of Tsallis entropy.

Ciprian TUDOR (Univ. of Lille, France)

Drift parameter estimation for the stochastic wave equation with space-time white noise

Abstract: We study the quadratic variations (in time and in space) of the solution to the stochastic wave equation driven by the space-time white noise. We give their limit (almost surely and in $L^2(\Omega)$) and we prove that these variations satisfy, after a proper renormalization, a Central Limit Theorem. We apply the quadratic variation to define and analyze estimators for the drift parameter of the wave equation.

Gheorghiță ZBĂGANU ("Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Romania)

Some conjectures about multidimensional ordering

Abstract: Let $Z_n=(X_n,Y_n)$ be sequence of i.i.d. random vectors with integer values Suppose that X_n and Y_n are independent. Let S_X and S_Y be their support. We are interested in the following problem: Let a_n be the probability that among the vectors Z_1, Z_2, ..., Z_n one of them is maximum.

Conjecture

If S_X or S_Y are finite, then lim a_n >0.

If both S_X and S_Y are infinite, then lim a_n=0.