19th International Summer Conference on Probability and Statistics (ISCPS'25)

July 24 – 27, 2025, Sofia, Bulgaria

Workshop on Branching Processes and Applications
Models for longitudinal, clustered or multivariate data (invited session)

The joint event is organized by

Faculty of Mathematics and Informatics
Sofia University

Institute of Mathematics and Informatics
Bulgarian Academy of Sciences

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About

The aim of the 19th International Summer Conference on Probability and Statistics is to bring together a wide range of researchers and graduate students working on various topics in probability and statistics, such as:

- Branching processes
- Stochastic processes
- Probabilistic and statistical analysis of discrete data
- Robust and nonparametric statistics
- Asymptotic methods in stochastics
- Econometric modelling and financial mathematics
- Stochastic modelling and risk analysis
- Statistical methods in genetics and systems biology
- Computer data analysis in applications
- Longitudinal data analysis
- Categorical data analysis
- Bayesian analysis
- Actuarial analysis

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Schedule ISCPS 2025

Thursday, July 24th

09:30–10:00	**Registration**
10:00–10:30	**Opening**

Keynote talk **Chair: Ralitza Gueorguieva**

10:30–11:30	**Yoav Benjamini** Tel Aviv University	Selective Inference: Challenges in Statistics and Stochastics
11:30–12:00	**Coffee break**	

Session 1: Random environment/reinforsed Galton-Watson branching processes
Chair: Maroussia Bojkova

12:00–12:30	**Péter Kevei** University of Szeged	Branching processes with immigration in a random environment
12:30–13:00	**Bastien Mallein** Université de Toulouse	Malthusian exponents, survival and extinction of Reinforced Galton-Watson processes
13:00–14:30	**Lunch break**	

Session 2: Models for longitudinal, clustered or multivariate data I
Chair: Marco Bonetti

14:30–15:00	**Maria Iannario** University of Naples Federico II	Modeling Ordinal Ratings and 'Don't Know' Responses: A Multivariate Mixed Model Approach
15:00–15:30	**Sabrina Giordano** University of Calabria	Joint Modeling of Response Behaviors and Latent Traits Over Time
15:30–16:00	**Claudia Tarantola** University of Milan	Bayesian Mixture Modeling for Ordinal Data with Uncertainty: The CUP Approach
16:00–16:30	**Coffee break**	

Session 3: Continuous-state branching process **Chair: Mladen Savov**

16:30–17:00	**Víctor Rivero** CIMAT	Conditioning the logistic continuous-state branching process on non-extinction via total progeny
17:00–17:30	**Ollivier Hyrien** Fred Hutchinson Cancer Center	Waiting Time Until First Mutant in Multitype Age-Dependent Branching Processes with Time-Inhomogeneous Immigration
17:30–18:00	**Inés del Puerto** University of Extremadura	Fluctuation limit theorem for controlled branching processes with size-divisibility properties
18:00–18:30	**Poster session**	
18:30	**Welcome reception**	

Friday, July 25th

Session 4: Branching processes modeling - statistics, simulation and time series
Chair: Inés del Puerto

10:00–10:30	**Anand Vidyashankar** George Mason University	Branching processes under distributional uncertainty
10:30–11:00	**Mátyás Barczy** University of Szeged	Axiomatic characterisation of generalized ψ-estimators
11:00–11:30	**Márton Ispány** University of Debrecen	Branching process models for integer-valued periodic and vector time series
11:30–12:00	**Coffee break**	

Session 5: Sofia session **Chair: Eugenia Stoimenova**

12:00–13:30	**Assen Tchorbadjieff** Institute of Mathematics and Informatics, BAS	Inference of Simulated Branching Processes
12:30–13:00	**Nikolay Nikolov** Institute of Mathematics and Informatics, BAS	Benjamini-Hochberg procedure under positive dependency with block structure
13:00–14:30	**Lunch break**	

Session 6: Models for longitudinal, clustered or multivariate data II
Chair: Claudia Tarantola

14:30–15:00	**Marco Bonetti** Bocconi University	Multivariate shared frailty models for survival and binary outcomes
15:00–15:30	**Neyko Neykov** National Institute of Meteorology and Hydrology	Robust Statistical Modeling in Regression Settings via Trimming
15:30–16:00	**Christos Nakas** University of Thessaly	Inference on the covariate-specific Overlap Coefficient (OVL)
16:00–16:30	**Coffee break**	

Session 7: Statistics of branching processes **Chair: Ollivier Hyrien**

16:30–17:00	**Giacomo Francisci** Ulm University	Additive martingales for autoregressive processes on Galton-Watson trees
17:00–17:30	**Dániel Bezdány** University of Szeged	Asymptotic behavior of some critical decomposable multi-type Galton–Watson processes with immigration
17:30–18:00	**Maroussia Slavtchova-Bojkova** Sofia University	Multitype continuous-time branching processes with immigration generated by point processes

Saturday, July 26th

Session 8: Statistical Learning **Chair: Daniela Tabakova**

10:00–10:30	**Nikola Konstantinov** INSAIT	Statistical Learning Under Distribution Shift
10:30–11:00	**Kristian Minchev** INSAIT	LARP: Learner-Agnostic Robust Data Prefiltering
11:00–11:30	**Antonia Arsova** TU Dortmund University	Probabilistic forecasting and forecast reconciliation for wind power production
11:30–12:00	**Coffee break**	

Session 9: Actuarial and Financial Mathematics Chair: Nikola Konstantinov

12:00–12:30	**Daniela Tabakova** MIB Trieste School of Management	Stochastic assessment of special-rate life annuities
12:30–13:00	**Dragomir Nedeltchev** Institute of Mathematics and Informatics, BAS	Challenges of applying Entropic VaR to models with stochastic volatility
13:00–14:30	**Lunch break**	

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19:00 **Conference Dinner** – Chevermeto restaurant (at NDK, Bulgaria Square 1)

Sunday, July 27th

Session 10: Special branching processes models Chair: Anand Vidyashankar

10:00–10:30	**Alex Watson** University College London	A growth-fragmentation found in the cone excursions of Brownian motion (and in the quantum disc)
10:30–11:00	**Nathalie Krell** Université Rennes 2	Branching processes and bacterial growth
11:00–11:30	**Coffee break**	
11:30–12:00	**Kata Kubatovics** University of Szeged	Branching processes in nearly degenerate varying environment
12:00–12:30	**Closing**	

List of Abstracts – Talks

Thursday, July 24th

Selective Inference: Challenges in Statistics and Stochastics

Yoav Benjamini

Tel Aviv University, Israel

Selective inference is the common practice of inspecting the results of many inferences, be they tests, confidence intervals or estimators, and selecting for highlighting the most promising ones. This practice deteriorates the probabilistic error-rate guarantees such methods were designed to offer. I shall discuss various approaches to address this problem emphasising the solution offered by the false discovery rate. In particular, I shall discuss the statistical problems arising in reporting the results of clinical studies as well as some long-standing probability inequalities awaiting proofs.

Branching processes with immigration in a random environment

Péter Kevei

University of Szeged, Hungary

We consider subcritical Galton-Watson branching processes with immigration, where the offspring distributions are determined by an iid random environment. Assuming that the branching mechanism is subcritical the process has a unique stationary distribution under weak conditions on the immigration. We are interested in the tail behavior of the stationary distribution. We consider the scenarios when the tail is determined by the offspring distribution, and when it is determined by the immigration distribution. In the first case we use Goldie's implicit renewal theory. In both cases we show that under general assumptions the stationary distribution has regularly varying tail.

Part of the talk is joint work with Bojan Basrak (Zagreb).

Malthusian exponents, survival and extinction of Reinforced Galton-Watson processes

Bastien Mallein

Université de Toulouse, France

Galton-Watson process is a classical stochastic model for describing the evolution of a population over discrete. In this process, every individual independently produces offspring according to a fixed distribution ν. Writing Z_n^{GW} for the number of individuals at generation n, it is well-known that

$$\mathbb{E}(Z_n^{\mathrm{GW}}) = m^n \text{ and } \mathbb{P}(Z_n^{\mathrm{Gw}} \to \infty) > 0 \iff m > 1.$$

We introduce a reinforced version of the Galton-Watson process, with parameters ν and $q \in (0,1)$, such that every individual in the process reproduces as follows: with probability $1-q$, it gives birth to children according to the law ν, while with probability q it chooses one of its ancestors uniformly at random and gives birth to the same number of children as that ancestor.

Denoting by Z_n the number of individuals alive at generation n in this process, we study the asymptotic behaviour of $\mathbb{E}(Z_n)$, give conditions for $\mathbb{P}(Z_n \to \infty) > 0$ and describe the empirical ancestral offspring distribution of individuals at large times.

This is joint work with Jean Bertoin.

Modeling Ordinal Ratings and ’Don’t Know’ Responses: A Multivariate Mixed Model Approach

Maria Iannario

University of Naples Federico II, Italy

Multivariate ordinal data from surveys often exhibit between-subject heterogeneity and varying response styles, with many surveys including a don’t know’ option that partially disrupts the ordinal structure. Standard models for ordinal data become inadequate in the presence of such complexity, while nominal models lack both efficiency and interpretability. Ignoring don’t know’ responses risks introducing bias, as non-respondents may differ systematically from respondents, potentially affecting the accuracy of the results.

Our approach introduces a flexible multivariate mixed modeling framework that jointly models the selection of don’t know responses and ordinal ratings. This model accounts for between-subject heterogeneity, varying response styles, and the effects of covariates. Likelihood-based inference is employed, with comprehensive model comparisons to ensure robustness. An application to financial risk perception, supported by a simulation study, illustrates the effectiveness of our approach. The mixture model provides unbiased, efficient, and interpretable results, offering a valuable tool for analyzing complex survey data with don’t know responses.

This is joint work with Ralitza Gueorguieva.

Maria Iannario gratefully acknowledges the support of the Marie Sk lodowska-Curie Actions under the European Union’s Horizon Europe research and innovation program for the Industrial Doctoral Network on Digital Finance (acronym: DIGITAL, project no. 101119635) and PRIN 2022 - CUP: E53C24002270006

Joint Modeling of Response Behaviors and Latent Traits Over Time

Sabrina Giordano

University of Calabria, Italy

Likert-scale surveys are widely used to assess opinions and perceptions, but their validity is often compromised by systematic response behaviors that mask respondents' true attitudes. Instead of reflecting true preferences, individuals may repeatedly select the midpoint or extremes of the scale, or habitually agree or disagree with items regardless of content. These tendencies, referred to as middle, extreme, acquiescence, and disacquiescence response styles (RS), produce biased results. To address this challenge, we propose an Hidden Markov Model (HMM) for longitudinal ordered categorical data that simultaneously models the temporal dynamics of both observable responses and unobservable response styles through a two-component latent structure.

The model identifies latent subgroups with different dynamics of a latent categorical trait of interest while accounting for RS-driven responses, accommodates the evolution of different response styles over time, employs parsimonious distributions for RS responses, incorporates covariates influencing initial and transition probabilities for both latent constructs and response style indicators, and utilizes stereotype logit models for latent construct probabilities.

The work provides detailed estimation procedures, standard error computations, goodness-of-fit and classification metrics, as well as full-conditional residuals for model diagnostics. This methodology is particularly valuable in research contexts where disentangling true attitudes and response behaviors is crucial to avoid misleading results. Potential applications include studies on subjective health assessments in healthcare, customer satisfaction in marketing, public opinion on socially sensitive topics in socio-economic research, and perceptions of environmental or financial risks, among others.

References

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Bayesian Mixture Modeling for Ordinal Data with Uncertainty: The CUP Approach

Claudia Tarantola

University of Milan, Italy

This contribution explores a Bayesian framework for analyzing ordinal data characterized by uncertainty or response ambiguity. We focus on the Cumulative-Uncertainty Preference (CUP) model, a novel two-component mixture model that combines a standard cumulative ordinal regression with a discrete Uniform distribution, designed to capture non-informative or uncertain responses.

The analysis relies on Markov Chain Monte Carlo (MCMC) methods to approximate the posterior distributions of model parameters, addressing challenges related to identifiability, mixing, and prior specification. Preliminary simulation results highlight the flexibility of the CUP model in recovering underlying structures, while also exposing open issues in parameter inference under different prior settings.

This ongoing research opens the path toward more interpretable and robust modeling of rating data in the presence of cognitive uncertainty or disengaged behavior, with potential applications in survey analysis, digital financial literacy, cyber risk assessment.

This is joint work with Maria Iannario (University Federico II of Naples) and Maria Kateri (RWTH Aachen University).

Conditioning the logistic continuous-state branching process on non-extinction via total progeny

<u>Víctor Rivero</u>

CIMAT, Mexico

The problem of conditioning a continuous-state branching process with quadratic competition (logistic CB process) on non-extinction is investigated. We first establish that non-extinction is equivalent to the total progeny of the population being infinite. The conditioning we propose is then designed by requiring the total progeny to exceed arbitrarily large exponential random variables. This is related to a Doob's h-transform with an explicit excessive function h. The h-transformed process, i.e. the conditioned process, is shown to have a finite lifetime almost surely (it is either killed or it explodes continuously). When starting from positive values, the conditioned process is furthermore characterized, up to its lifetime, as the solution to a certain stochastic equation with jumps. The latter superposes the dynamics of the initial logistic CB process with an additional density-dependent immigration term. Last, it is established that the conditioned process can be starting from zero. Key tools employed are a representation of the logistic CB process through a time-changed generalized Ornstein-Uhlenbeck process, as well as Laplace and Siegmund duality relationships with auxiliary diffusion processes.

Waiting Time Until First Mutant in Multitype Age-Dependent Branching Processes with Time-Inhomogeneous Immigration

Ollivier Hyrien

Biostatistics, Bioinformatics, and Epidemiology Program, Vaccine and Infectious Disease Division, Fred Hutchinson Cancer Center, Seattle, USA

We consider the time-to-first-mutant problem for multitype age-dependent branching processes with time-inhomogeneous immigration. This problem concerns the time at which the first individual of a given type, or set of types, referred to as mutants, appears in the population, either through immigration or reproduction. It provides insights into the waiting time for specific events to occur, such as the appearance of certain mutations in the genome of a virus or cell, and the pace at which types diversify within a population. The problem finds applications in many fields, including genetics, cancer research, immunology, and epidemiology. We study four first-birth times, provide explicit formulas for their distributions, and derive limiting distributions along with associated convergence rates. Finally, we illustrate the results with several applications.

The talk is based on joint work with Nikolay M. Yanev (Institute of Mathematics and Informatics, Bulgarian Academy of Sciences).

Fluctuation limit theorem for controlled branching processes with size-divisibility properties

Inés del Puerto

University of Extremadura, Spain

In this talk, we address the study of the convergence of rescaled sequences of controlled branching processes in the Skorokhod space. This problem is sometimes referred to in the literature as scaling limit theorems or high-density limit theorems. We investigate a sequence of controlled branching processes, introducing the novel feature that the control functions incorporate a term exhibiting size-divisibility properties. Our objective is to establish a set of sufficient conditions ensuring the weak convergence of this sequence to a continuous-time, continuous-state branching process with dependent immigration.

This is joint work with Pedro Martín-Chávez and M. González.

Friday, July 25th

Branching processes under distributional uncertainty

Anand Vidyashankar

George Mason University, USA

In biological, epidemiological, and statistical applications of branching processes, the true offspring distribution is typically unknown, complicating inference about critical characteristics such as supercriticality, criticality, and subcriticality. Erroneous assumptions about these regimes can severely bias conclusions. To address this, we investigate branching processes under distributional uncertainty, focusing on ambiguity sets characterized by constraints on the KullbackLeibler divergence from a nominal offspring distribution. We characterize robust thresholds delineating supercritical, critical, and subcritical regimes. Furthermore, we derive robust analogs of classical limit laws, including robust versions of the Kesten-Stigum theorem and Yaglom's theorem, as well as results concerning extinction probabilities, thereby highlighting how distributional robustness significantly affects asymptotic behavior and the probability of long-term survival.

Axiomatic characterisation of generalized ψ-estimators

Mátyás Barczy

University of Szeged, Hungary

We introduce the notion of generalized ψ-estimators as unique points of sign change of some appropriate functions. This notion is a generalization of usual ψ-estimators (also called Z-estimators). We give necessary as well as sufficient conditions for the (unique) existence of generalized ψ-estimators. Our results are well-applicable in statistical estimation theory, for example, in case of empirical quantiles, empirical expectiles, some (usual) ψ-estimators in robust statistics, and some maximum likelihood estimators as well.

Furthermore, we give axiomatic characterisations of generalized ψ-estimators and (usual) ψ-estimators, respectively. The key properties of estimators that come into play in the characterisation theorems are the symmetry, the (strong) internality and the asymptotic idempotency. In the proofs, a separation theorem for Abelian subsemigroups plays a crucial role.

This is joint work with Zsolt Páles (University of Debrecen). The talk is based on our papers [1], [2] and [3].

Mátyás Barczy has been supported by the project TKP2021-NVA-09. Project no. TKP2021-NVA-09 has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-NVA funding scheme.

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Branching process models for integer-valued periodic and vector time series

Márton Ispány

University of Debrecen, Hungary

Nowadays, there is a growing interest in time series comprised of non-negative integers or counts, see the survey [1]. Count time series arise in fields, such as agriculture, economics, epidemiology, finance, geology, meteorology, and sports. The count time series analog of the well-known autoregressive and moving average (ARMA) model is the integer-valued ARMA (INARMA) model. This is a kind of extension of branching process with immigration (BPI) with Bernoulli offspring distribution. In practice, some time series exhibit periodic behavior in their autocovariance structure. A generalization of the integer-valued autoregressive (INAR) model for describing periodic count time series is the periodic INAR (PINAR) model. A particular example of the PINAR model, namely PINAR$(1, 1_S)$ where S is the period, is introduced in [2] and discussed in detail in [3]. In the talk, we will give an overview of BPI modeling of count time series, both periodic and vector-valued ones.

A periodic $\mathbb{N}_0$-valued ARMA process $\{Y_t\}$, called generalized PINARMA process, with seasonal period $S \in \mathbb{N}$ is defined by the periodic stochastic difference equation

$$Y_t = \sum_{i=1}^{p_t} \sum_{k=1}^{Y_{t-i}} \xi_{i,k}^t + \sum_{j=0}^{q_t} \sum_{\ell=1}^{\varepsilon_{t-j}} \eta_{j,\ell}^t, \quad t \in \mathbb{Z}. \tag{0.1}$$

In (0.1), $p_t, q_t \in \mathbb{N}_0$ for all $t \in \mathbb{Z}$, $\{\xi_{i,k}^t, \eta_{j,\ell}^t, \varepsilon_t\}$ are mutually independent $\mathbb{N}_0$-valued random variables such that $\{\xi_{i,k}^t \mid k \in \mathbb{N}\}$ and $\{\eta_{j,\ell}^t \mid \ell \in \mathbb{N}\}$ are identically distributed for all $t \in \mathbb{Z}$, $i \in \mathbb{N}$, and $j \in \mathbb{N}_0$. We assume that the expectations $\alpha_i^t := \mathsf{E}(\xi_{i,1}^t)$, $\beta_j^t := \mathsf{E}(\eta_{j,1}^t)$, and $\lambda_t := \mathsf{E}(\varepsilon_t)$ exist and are finite for all $t \in \mathbb{Z}$, $i \in \mathbb{N}$, and $j \in \mathbb{N}_0$. The input random vectors $\boldsymbol{\epsilon}_k := (\varepsilon_{kS+S}, \dots, \varepsilon_{kS+1})^\top$, $k \in \mathbb{Z}$, are independent identically distributed but the input random variables may be dependent in a period. The non-negative real numbers $\boldsymbol{A} := \{\alpha_i^t\}$ and $\boldsymbol{B} := \{\beta_j^t\}$ are called autoregressive and moving average coefficients, respectively, and $\{\lambda_t\}$ are referred to as input intensities. We assume that all series $\{p_t\}$, $\{q_t\}$, $\{\alpha_i^t \mid t \in \mathbb{Z}\}$, $\{\beta_j^t \mid t \in \mathbb{Z}\}$, and $\{\lambda_t\}$ are periodic functions with period S. Recall that a sequence of real numbers $\{x_t\}$ is periodic with period S when $x_{t+S} = x_t$ for all $t \in \mathbb{Z}$. The vectors $\boldsymbol{p} = (p_s) \in \mathbb{N}_0^S$ and $\boldsymbol{q} = (q_s) \in \mathbb{N}_0^S$ are called the autoregressive and moving average orders of the model. If $S = 1$, then the process is time stationary. Note that Y_{kS+s} denotes the series during the sth season of period k. For example, in the case of monthly data and yearly seasonality, $S = 12$, s is the month of the year, and k is the index of the year.

Define the state vectors of the process $\{Y_t\}$ as $\boldsymbol{Y}_k := (Y_{kS+S}, \dots, Y_{kS+1})^\top$, $k \in \mathbb{Z}$, and consider the $\mathbb{N}_0^S$-valued stochastic processes $\{\boldsymbol{Y}_k\}$ and $\{\boldsymbol{\varepsilon}_k\}$. For the random sum, introduce the notation $\xi \circ Y := \sum_{j=1}^{Y} \xi_j$ where the counting sequence $\{\xi_j\}$ consists of independent copies of ξ which are independent of Y. The symbol $\circ$ is called the generalized thinning operator. The matricial thinning operator $\Xi\circ = (\xi_{i,j}\circ)$ of dimension $S \times S$ is defined as $(\Xi \circ \boldsymbol{Y})_i := \sum_{j=1}^{S} \xi_{i,j} \circ Y_j$, $i = 1, \dots, S$. Then, for all $k \in \mathbb{Z}$, we obtain the following state equation

$$\boldsymbol{Y}_k = \sum_{i=0}^{p} \boldsymbol{A}_i^k \circ \boldsymbol{Y}_{k-i} + \sum_{j=0}^{q} \boldsymbol{B}_j^k \circ \boldsymbol{\varepsilon}_{k-j}, \quad k \in \mathbb{Z}, \tag{0.2}$$

where $\{\boldsymbol{A}_i^k\circ \mid k \in \mathbb{Z}\}$, $i = 0, 1, \dots, p$, and $\{\boldsymbol{B}_j^k\circ \mid k \in \mathbb{Z}\}$, $j = 0, 1, \dots, q$, are i.i.d. matricial thinning operators of dimension $S \times S$ defined by counting sequences in (0.1) and the autoregressive and moving average orders p and q depend on $\boldsymbol{p}$ and $\boldsymbol{q}$, respectively. The matricial thinning operators $\boldsymbol{A}_0^k\circ$'s and $\boldsymbol{B}_0^k\circ$'s are strictly upper triangular and upper triangular, respectively. The mean matrices $A_i := \mathsf{E}(\boldsymbol{A}_i^k\circ)$, $i = 0, 1, \dots, p$, and $B_j := \mathsf{E}(\boldsymbol{B}_j^k\circ)$, $j = 0, 1, \dots, q$, $k \in \mathbb{Z}$, are nonnegative and called autoregressive and moving average coefficient matrices, respectively. Equation (0.2) is an implicit state-space representation of a PINARMA process. The vector process $\{\boldsymbol{Y}_k\}$ is called VINARMA process of orders p and q. Note that $\{\boldsymbol{A}_i^k\circ, \boldsymbol{B}_j^k\circ, \boldsymbol{\varepsilon}_k\}$ form a mutually independent set.

A spectral criterion, $\rho(A_0 + A_1 + \ldots + A_p) < 1$, where ρ denotes the spectral radius, is derived for the existence and uniqueness of a stationary solution to a VINARMA model (0.2). By this result, using the backward periodic mean matrix of a PINARMA process, a spectral condition is given for the existence of a unique solution to the model (0.1). Two infinite series representations, the two-part moving average, and the immigrant generation, of a VINARMA process are established. The structure of the mean and covariance functions of a periodically stationary distribution of PINARMA model and a stationary distribution of VINARMA model is derived. Real data applications are also presented.

Keywords: branching process with immigration, binomial thinning, count time series, INARMA model, periodicity

Mathematics Subject Classification (2020): Primary 60J80, 62M10; Secondary 60J10, 62M15

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Inference of Simulated Branching Processes

Assen Tchorbadjieff

Institute of Mathematics and Informatics, Bulgarian Academy of Sciences

The evolution of any branching particle system depends on naturally driven reproduction law and the lifetime of particles. However, this process is opaque and remains unobserved during occurring events. Only available data are initial conditions and final outcome, or the cause and the effect. An analytical approach is to estimate the statistical distribution by asymptotic laws. The alternative empirical approach implements computations using stochastic simulation methods. Using the supercomputer facility, we are presenting a preliminary study of reproduction mechanisms based on Negative Binomial and Poisson distributions.

Benjamini-Hochberg procedure under positive dependency with block structure

Nikolay I. Nikolov

Institute of Mathematics and Informatics, Bulgarian Academy of Sciences &
Sofia University "St. Kliment Ohridski"

The Benjamini-Hochberg (B-H) procedure, introduced in [1], is a method for controlling the false discovery rate (FDR) in the problem of multiple testing, common in biomedical and genomic research. The asymptotic convergence of the B-H method is well studied in the case of independent tests, e.g. [3]. The Benjamini-Yekutieli (B-Y) method was proposed in [2] to control the FDR when the tests are dependent. In this talk, we consider a special dependence structure which is associated with a block design for the covariance matrix of the underlying test statistics. We propose an algorithm for estimating the unknown dependency parameters and a method for calibrating the B-H procedure. The performance of the new method is compared to the B-H and B-Y procedures via a simulation study.

The talk is based on joint work with Dean Palejev (IMI-BAS, FMI-SU) and Mladen Savov (FMI-SU, IMI-BAS).

This study is financed by the European Union's NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No BG-RRP-2.004-0008.

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Multivariate shared frailty models for survival and binary outcomes

Marco Bonetti

Bocconi University, Italy

We discuss the problem of predicting the risk of onset (or detection) of breast cancer, with a specific interest in the effect of family history of the disease.
We suggest a shift in perspective from traditional approaches, by modelling families as the unit of analysis rather than individuals. By investigating the latent family-specific risk underlying breast cancer diagnoses, we construct a parametric multivariate shared frailty cure-rate model. This model captures the familial risk as a shared frailty among members, and explicitly accounts for a cured fraction of women who are not susceptible to breast cancer. We aim to identify the highest-risk families to better target screening and prevention, ultimately improving early detection. A comparative analysis with Cox and univariate models - where a binary risk indicator acts as a "best guess" for the latent high-risk group - is carried out through simulation studies and real data from the Swedish Multi-Generational Breast Cancer registry. Risk prediction performance is assessed using AUC and Harrell's c-index. We demonstrate the importance of using the complete family history of breast cancer to accurately identify high-risk families, and show that the multivariate shared frailty cure-rate model enhances both explanatory power and prediction accuracy.
We then introduce a related, novel mixed model for longitudinal binary data. We exploit the Lehmann structure to allow for a closed form expression of the observed data likelihood, thus allowing for fast and precise estimation of the model parameters. Here, too, posterior prediction of the individual-level risk is performed. The motivating application consists of the individual adherence pattern of women to breast cancer screening invitations. The goal is the identification of the women who are hesitant above and beyond what can be explained by measured risk factors, so that individual adherence-promoting interventions may be entertained.

This is joint work with Maria Veronica Vinattieri (Karolinska Institutet) and Edoardo Ratti (University of Milan - Bicocca).

The work is supported in part by the MUSA – Multilayered Urban Sustainability Action – project, funded by the European Union – Next Generation EU, under the National Recovery and Resilience Plan (NRRP) Mission 4 Component 2 Investment Line 1.5.

Keywords: Multivariate survival models, Family history, Mixed models.

Robust Statistical Modeling in Regression Settings via Trimming

Neyko Neykov

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Robust estimation and robust modelling represent two distinct strategies in statistics and data analysis for addressing the presence of outliers in regression settings. Over the past five decades, a wide range of robust estimators have been developed and studied [1]. While robust estimation typically relies on modified loss functions to reduce the influence of the outliers in data, robust modelling instead assumes a heavy-tailed distribution - such as the Student's t distribution - for the error terms.

The Maximum Likelihood Estimator (MLE) is commonly used to jointly estimate the location, scale and shape, copulas and finite mixture unknown parameters under the normal and Student's t distributions within the regression frameworks, [2], [3], [4]. Although heavy-tailed distributions like the Student-t improve resistance to vertical outliers in the response variable, they are often insufficient to mitigate the influence of dynamic outliers, the so called leverage points, which arise from contamination in the explanatory variables of both location and scale models. One vertical outlier effectively becoming high-leverage points in subsequent observations so the Student t distribution would not be able to neutralize their impact.

This talk highlights the limitations of conventional robust modeling approaches whithin these contexts and advocates the usage of the Maximum Trimmed Likelihood Estimator (MTLE) as an alternative, e.g., [5], [6], [7]. In particular, the paper characterizes the breakdown point of the MTLE as a prominent prominent measure of robustness within these settings. The improved performance of the MTLE is further supported through examples and detailed simulation study.

The talk is based on joint work with Vladimir Vutov (Medical Faculty, Heidelberg University).

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Inference on the covariate-specific Overlap Coefficient (OVL)

Christos T. Nakas

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The Overlap Coefficient (OVL) quantifies the similarity between two probability distributions by measuring the area of overlap between their distribution functions. Owing to its intuitive interpretation and ease of graphical representation via overlapping histograms, OVL is a valuable tool in various applied research contexts, including bioequivalence testing and diagnostic accuracy studies. Despite its usefulness, inferential methods and software implementations for OVL remain limited, especially for diverse distributional scenarios and covariate-specific applications. This paper develops both parametric and nonparametric methodologies for constructing accurate confidence intervals for the OVL. A novel covariate-specific OVL estimator is introduced using linear regression models, with optional Box-Cox transformation, allowing for adjustment of covariate effects on distributional overlap. Parametric approaches based on the binormal model are proposed and shown to perform well across a range of scenarios. All methods are evaluated through extensive simulation studies. Practical applications are demonstrated using data from two clinical studies: cognitive function assessments in an HIV-related cohort and post-prandial blood glucose measurements in diabetes patients adjusted for age. R code and a relevant package have been developed to facilitate implementation in applied settings.

This is joint work with M. Carmen Pardo and A. M. Franco-Pereira (Department of Statistics and O.R. & Instituto de Matemática Interdisciplinar, Complutense University of Madrid), and B. Reiser (Department of Statistics, University of Haifa).

Keywords: Bootstrap, Box-Cox transformation, delta method, kernel methods, regression modeling, ROC curves

Additive martingales for autoregressive processes on Galton-Watson trees

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The branching random walk model starts at time 0 with a single ancestor $\emptyset$ at the origin. The ancestor produces a random number of children whose positions are given by a point process $Y_\emptyset$. This course continues over generations with every new individual v producing offspring that each move randomly from their parents' position. The number of offspring and the displacement of their positions from their parents' are given by i.i.d. point processes $\{Y_v\}$. We study a generalization of this model that incorporates an autoregressive structure along with the point processes representing the positions. Specifically, at each time, the parent position is multiplied by a factor of $\rho \in \mathbb{R}$. The case $\rho = 1$ corresponds to the classical branching random walk. The model exhibits a substantially different behavior depending on whether $|\rho|$ is smaller or larger than one. In both the cases, we study convergence of a version of the additive martingale for the positions at generation n and establish an analogue of Kesten-Stigum theory for these processes.

The talk is based on joint work with Anand N. Vidyashankar (Department of Statistics, George Mason University).

Keywords: Branching processes, Branching random walks, Autoregressive models, Additive martingales.

MSC: 60J80, 60G50, 62M10, 60G42.

Asymptotic behavior of some critical decomposable multi-type Galton–Watson processes with immigration

Dániel Bezdány

Bolyai Institute, University of Szeged, Szeged, Hungary

We study the asymptotic behavior of a critical decomposable multi-type Galton–Watson processes with immigration whose offspring mean matrix is triangular with diagonal entries 1. Under second or fourth order moment assumptions on the offspring and immigration distributions, we establish a functional limit theorem for the sequence of appropriately scaled processes, which generalizes the results of Barczy and Bezdány [1]. The coordinate processes of the limit process may be described as independent squared Bessel processes and iterated integral processes of their linear combinations. In the proofs we use limit theorems for martingale differences towards a diffusion process due to Ispány and Pap [2].

The talk is based on joint work with Mátyás Barczy (HUN-REN–SZTE Analysis and Applications Research Group, Bolyai Institute, University of Szeged).

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Multitype continuous-time branching processes with immigration generated by point processes

Maroussia Slavtchova-Bojkova

Sofia University "St. Kliment Ohridski" &
Institute of Mathematics and Informatics, Bulgarian Academy of Sciences

Following the pivotal work of Sevastyanov [1], who considered branching processes with homogeneous Poisson immigration, much has been done to understand the behaviour of such processes under different types of branching and immigration mechanisms. Recently, the case where the times of immigration are generated by a non-homogeneous Poisson process was considered in depth. In this work, we try to demonstrate how one can use the framework of point processes in order to go beyond the Poisson process. As an illustration, we show how to transfer techniques from the case of Poisson immigration to the case where it is spanned by a determinantal point process.

The talk is based on joint work with Martin Minchev (Sofia University), [2].

This study is financed by the European Union's NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No BG-RRP-2.004-0008.

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Saturday, July 26th

Statistical Learning Under Distribution Shift

Nikola Konstantinov

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Machine learning (ML) methods excel at extracting useful patterns from large scale data and using the learned patterns for making accurate predictions. A crucial assumption underpinning the theoretical backing of ML is that the learning environment is stationary, or, in statistical terms, that the data encountered at train and test time is drawn from the same distribution. Unfortunately, this assumption rarely holds in practice, where ML is often trained and tested in unreliable and/or adaptive environments. In this talk, I will present approaches towards providing statistical guarantees for ML algorithms under two types of distribution shift. Firstly, I will discuss learning from contaminated training data, a common situation in collaborative and federated learning settings. Secondly, I will present methods for learning under performative effects, where the test distribution may change as a function of the deployed classifier, as commonly observed in social applications of ML.

LARP: Learner-Agnostic Robust Data Prefiltering

Kristian Minchev

INSAIT, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

The widespread availability of large public datasets is a key factor behind the recent successes of statistical inference and machine learning methods. However, these datasets often contain some low-quality or contaminated data, to which many learning procedures are sensitive. Therefore, the question of whether and how public datasets should be prefiltered to facilitate accurate downstream learning arises. On a technical level this requires the construction of principled data prefiltering methods which are *learner-agnostic robust*, in the sense of provably protecting a set of pre-specified downstream learners from corrupted data. In this work, we formalize the problem of **L**earner-**A**gnostic **R**obust data **P**refiltering (LARP), which aims at finding prefiltering procedures that minimize a worst-case loss over a pre-specified set of learners. We first instantiate our framework in the context of scalar mean estimation with Huber estimators under the Huber data contamination model. We provide a hardness result on a specific problem instance and analyze several natural prefiltering procedures. Our theoretical results indicate that performing LARP on a heterogeneous set of learners leads to some loss in model performance compared to the alternative of prefiltering data for each learner/use-case individually. We explore the resulting utility loss and its dependence on the problem parameters via extensive experiments on real-world image and tabular data, observing statistically significant reduction in utility. Finally, we model the trade-off between the utility drop and the cost of repeated (learner-specific) prefiltering within a game-theoretic framework and showcase benefits of LARP for large datasets.

The talk is based on joint work with Dimitar I. Dimitrov and Nikola Konstantinov (INSAIT).

Probabilistic forecasting and forecast reconciliation for wind power production

Antonia Arsova

Department of Statistics, TU Dortmund University, Germany

Forecast reconciliation is applied to ensure that forecasts for multiple time series on different levels of a hierarchy conform to the linear restrictions prescribed by the hierarchy. When reconciling probabilistic forecasts, this linear restriction is to be enforced on the distributional level. Building upon the approach of Panagiotelis et al. (European Journal of Operational Research, 306(2):693–706, 2023), who construct their reconciled forecasts as a linear function of the base-level forecasts, we construct the reconciled forecasts using a feedforward multilayer perceptron (MLP) neural network. One aim of our work is to study under which circumstances a linear reconciliation strategy is sufficient (and optimal) and when non-linear generalizations, such as the MLP, are needed. As an empirical application, the different reconciliation strategies are compared when applied to probabilistic one-step ahead forecasts for German wind-power production at three different spatial hierarchical levels.

The talk is based on joint work with Sven Pappert (TU Dortmund University).

Stochastic assessment of special-rate life annuities

Daniela Tabakova

Center for Insurance Research "Ermanno Pitacco", MIB Trieste School of Management, Trieste, Italy

A special-rate life annuity provides a guaranteed post-retirement income, quoting premium rates tailored to the applicant's health status; more favourable annuity rates are applied in the presence of poorer health conditions, because of a lower life expectancy. Offering better annuity rates to individuals with lower life expectancy aims to stimulate the demand for annuities and expand the provider's portfolio, with a positive impact not only on expected results, but also on the pooling effect. However, a higher degree of heterogeneity of the pool follows, due to different risk classes defined during the product development process. In particular, there is evidence of a higher variance of the lifetime distribution for individuals with critical health conditions. Overall, higher variability of the total portfolio payout should be expected.

In this research we study the risk profile of a portfolio of special-rate annuities, considering the trade-off between the effects of an increased portfolio size and a greater heterogeneity. Numerical evaluations are based both on a deterministic and stochastic approach in respect of mortality and heterogeneity; this way, both the idiosyncratic and aggregate components of longevity risk are addressed. Our findings suggest that special-rate annuities may allow expanding insurers to expand their portfolio, without any significant impact on its risk profile because of a greater heterogeneity.

This is joint work with Annamaria Olivieri (Department of Economics and Management, University of Parma, Parma, Italy).

Keywords: Underwritten annuities, Standard annuities, Enhanced annuities, Impaired annuities, Preferred risks, Substandard risks, Stochastich mortality, Longevity risk, Heterogeneity.

Challenges of applying Entropic VaR to models with stochastic volatility

Dragomir Nedeltchev

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Applying Value-at-Risk (VaR) to normally distributed log-returns is a common starting position in the financial mathematics to consider more sophisticated cases since closed-form formulas are available. The requirement to get the approach closer to the market realities necessitates introducing models with stochastic variance like Heston Model, Bates Model, Zaevski-Kim-Fabozzi Model, etc. The Heston Model casts the challenge to deal with the variance and its initial value that are both unobservable on the market, and also the need to apply Fast Fourier Transformation (FFT) to the Characteristic Function (CF) since no Probability Density Function (PDF) is available for the model. A more complicated approach is necessary when we have to find the upper bound of the Heston VaR with a coherent risk measure called Entropic VaR. Its computation involves the calculation of the Moment-Generating Function (MGF) which needs knowledge of the MGF existence zone and certainty about the current variance over the whole area. We solve these challenges by averaging the centered log-returns of the Heston Model over all possible variance values having in mind that the variance is Gamma-distributed.

Sunday, July 27th

A growth-fragmentation found in the cone excursions of Brownian motion (and in the quantum disc)

Alex Watson

University College London, United Kingdom

Consider a Brownian motion constrained to remain within a cone in the plane, and conditioned to exit it at its apex. As it explores this space, its path can be divided into sections living within smaller subcones with random apexes: cone excursions. Cutting out these excursions produces a process with jumps, and the procedure can be iterated indefinitely within the cut-out sections. What emerges is a growth-fragmentation, a type of branching process with infinite activity. We demonstrate this and characterise the law of the growth-fragmentation for a particular choice of apex angle. The resulting process can be seen as describing the boundary lengths of certain SLE curves drawn on a quantum disc, and mirrors parallel developments in the field of random planar maps. A key element in the work is an interesting pathwise construction of the 3/2-stable process conditioned to stay positive.

This is joint work with Ellen Powell (Durham) and William Da Silva (Vienna).

Branching processes and bacterial growth

Nathalie Krell

Université Rennes 2, France

We investigate the modeling of bacterial growth through the construction of a multi-type branching process. Specifically, we consider the evolution of a cell population using a piecewise deterministic Markov branching tree. In this model, each cell divides into two offspring at a division rate that depends on its size x, while its size grows exponentially over time with an individual-specific growth rate. Building on the model introduced by Doumic, Hoffmann, Krell, and Robert (2015), we extend the framework to distinguish between two bacterial types: those with a young pole and those with an old pole. We demonstrate that the proposed branching process is rigorously defined and satisfies a many-to-one formula. Furthermore, we establish that the mean empirical measure of this process converges to a growth-fragmentation equation, where size, growth rate, and type serve as state variables. I will conclude by discussing ongoing work, in collaboration with Benoîte de Saporta, Bertrand Cloez, and Tristan Roget, focusing on the estimation of division rates in the twotype setting.

The talk is based on joint work with Bertrand Cloez, Benoîte de Saporta and Tristan Roget.

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Branching processes in nearly degenerate varying environment

Kata Kubatovics

Bolyai Institute, University of Szeged, Hungary

We investigate branching processes in varying environment, for which $\overline{f}_n \to 1$ and $\sum_{n=1}^{\infty}(1-\overline{f}_n)_+ = \infty$, $\sum_{n=1}^{\infty}(\overline{f}_n - 1)_+ < \infty$, where $\overline{f}_n$ stands for the offspring mean in generation n. Since subcritical regimes dominate, such processes die out almost surely, therefore to obtain a nontrivial limit we consider two scenarios: conditioning on non-extinction, and adding immigration. In both cases we show that the process converges in distribution without normalization to a nondegenerate compound-Poisson limit law.

We also prove functional limit theorems in the above cases. In the former case, the limiting process is a time-changed simple birth-and-death process on $(-\infty, 0]$ conditioned on survival at 0, while in the latter, it is a time-changed stationary continuous time branching process with immigration.

The talk is based on joint work with Péter Kevei (Bolyai Institute, University of Szeged).

List of Posters

- *Tests of stochastic dominance with repeated measurements data*, **Angel G. Angelov**, Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

  Abstract: We explore a testing problem which involves four hypotheses, i.e., based on observations of two random variables X and Y, we wish to discriminate between four possibilities: identical survival functions, stochastic dominance of X over Y, stochastic dominance of Y over X, or crossing survival functions. Four-decision testing procedures for repeated measurements data are proposed. The tests are based on a permutation approach and do not rely on distributional assumptions. One-sided versions of the Cramer–von Mises, Anderson–Darling, and Kolmogorov–Smirnov statistics are considered. The consistency of the tests is shown. A simulation study indicates good power properties and control of false-detection errors. The proposed tests are applied to data from a psychophysical experiment.

  The presentation is based on joint work with Magnus Ekström.

- *Branching processes with random migration: nonparametric maximum likelihood estimation*, **Tsvetomira A. Zlatkova**, Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

  Abstract: We consider the branching processes with random migration (BPRM) that were studied in [3], [2], and many others. For these models, Yanev and Nitcheva [1] proposed estimators for the offspring mean, m, and the migration mean, M, using only the sizes of the generations. We study the case, where the entire family history (tree) is known. Using this information, we are able to derive nonparametric maximum likelihood estimators (MLEs) for additional parameters than the two mentioned above, including the migration probabilities and the probability mass functions of the distributions used in the model. Furthermore, we present numerical and graphical results from simulations of the BPRM.

  The presentation is based on joint work with Vessela K. Stoimenova (Sofia University).

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Useful Information

The host of the conference is the **Institute of Mathematics and Informatics** with address: *Acad. G. Bonchev Str., Block 8, Sofia 1113, Bulgaria*. Registration begins at **9:30** on **Thursday** (**July 24th**) next to the entrance of the Institute of Mathematics and Informatics. The conference room is **055** (underground floor).

The welcome reception will be on **Thursday** at **18:30**, while the conference dinner on **Saturday** at **19:00** (Chevermeto restaurant, NDK, Bulgaria Square 1).

Misc

- **Exchange rate:** The official exchange rate to euro is 1 EUR = 1.95583 BGN.
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