XVI LATIN AMERICAN CONGRESS OF PROBABILITY AND MATHEMATICAL STATISTICS

BOOK OF ABSTRACTS

IME - USP

JULY 10 - 14

IME.USP.BR/~16CLAPEM/

Contents

Short courses

The cutoff phenomenon for finite Markov chains

Justin Salez

Université Paris-Dauphine

The cutoff phenomenon is an abrupt phase transition in the convergence to equilibrium of certain Markov chains, in the limit where the number of states tends to infinity. Discovered in the 80's by Aldous, Diaconis and Shahshahani in the context of card shuffling, it has since then been independently observed in a variety of contexts, including random walks on graphs and groups, high-temperature spin glasses, or interacting particle systems. Nevertheless, a general theory is still missing, and identifying the general mechanisms underlying this mysterious phenomenon remains one of the most fundamental problems in the area of mixing times. The goal of this mini-course is to provide a self-contained introduction to this fascinating question, illustrated with many examples and a selection of open problems. I will also present a new approach based on entropy and curvature, which has recently led to a systematic proof of cutoff for a broad class of chains.

On the statistical theory of deep learning

Sophie Langer

University of Twente

Although Deep Learning has already reached the state of the art in many machine learning tasks, the underlying understanding of the methodology is still in its infancy. Most applications rely on intuition and trial and error. So far, we have only a limited understanding of

- Why we can reliably optimize non-convex objectives?
- How expressive our architectures are with respect to the class of hypotheses they describe?

- Why most complex models generalize to unseen examples when we use data sets orders of magnitude smaller than what classical statistical learning theory considers sufficient?

In this short course we cover the latest in deep learning theory from different perspectives. We start by analyzing the expressive power of neural networks and discuss why depth helps here. We derive statistical risk bounds for different statistical settings, learn about their proof strategies and also their limitations. We discuss optimization related results, analyze the energy landscape, discuss the implicit bias in gradient descent and learn about different regularization methods.

Plenary Conferences

Polynuclear growth and the KPZ fixed point

Daniel Remenik

Universidad de Chile

The KPZ universality class is a broad collection of probabilistic models including one-dimensional random growth, directed polymers and particle systems. At its center lies the KPZ fixed point, a special scaling invariant Markov process which governs the asymptotic fluctuations of all models in the class. The transition probabilities of the KPZ fixed point are known very explicitly, and they satisfy a famous integrable PDE, the KP equation. In this talk I will discuss these topics using the polynuclear growth model (PNG) as a starting point. This is a model for crystal growth in one dimension, which is intimately connected to the classical longest increasing subsequence problem for a uniformly random permutation. I will explain how PNG can be solved explicitly through probabilistic arguments, and how this solution yields a connection between PNG and another classical completely integrable system, the Toda lattice.

Phase diagram for the Complex Gaussian Multiplicative Chaos

Hubert Lacoin

Instituto de Matemática Pura e Aplicada (IMPA)

Gaussian Multiplicative Chaos (or GMC) is defined as the random distribution on $\mathbb{R}^d$ which is obtained by taking the exponential of a log-correlated field. It has been introduced by Kahane in the 85, in an effort to given a mathematical meaning to an informal model for dissipation of energy in turbulent fluids introduced a decade earlier by Mandelbrot. In the last two decades, the object has gathered the interest of a large community due to its connection with two dimensional Quantum field theories including Liouville Quantum gravity. Kahane's work was focused on studying $e^{\gamma X(x)}\mathrm{d}x$ where X is a real valued log correlated field and γ is a real parameter, but more recently, research efforts have been made to extend to construction to the remainder of the complex plane $\gamma \in \mathbb{C} \setminus \mathbb{R}$. The aim of this talk is to present results concerning the phase diagram of the complex GMC: for different regions of the complex plane we identify the proper renormalization and give a description of the measure which formally corresponds to $e^{\gamma X(x)}\mathrm{d}x$.

Random trees and their limits

Louigi Addario-Berry

McGill university

I will survey some recent work by myself and others on limits of random trees, with a focus on how bijective approaches (in particular line-breaking constructions) can be used to access distributional properties of a wide range of random tree models.

Long-term concentration of measure and cut-off

Malwina Luczak

University of Manchester

We present new concentration inequalities for Markov chains (in discrete and continuous time), generalising results for chains that are contracting in Wasserstein distance. We further extend the notion of cut-off to chains with infinite state space. We illustrate our results with examples. (Based on joint work with Andrew Barbour and Graham Brightwell.)

The contact process on dynamic random environments

Maria Eulália Vares

Universidade Federal do Rio de Janeiro

It is natural to consider simple models for the growth of an infection, such as the classical Harris contact process, when on the background we have an environment which is also random and evolves in time. This leads to a class of questions that set nice mathematical challenges as well. I plan to discuss a few different situations which have been object of recent research and some ongoing work, mostly in collaboration with M. Hilário, D. Ungaretti, and D. Valesin.

Funding: My research is partially supported by CNPq, Brazil grant 310734/2021-5, and by FAPERJ, Brazil CNE grant E-26/202.636/2019

Wasserstein-p bounds in the Central Limit Theorem under weak dependence

Morgane Austern

Harvard University

The central limit theorem is one of the most fundamental results in probability and has been successfully extended to locally dependent data and strongly-mixing random fields. In this paper, we establish its rate of convergence for transport distances, namely for arbitrary $p \geq 1$ we obtain an upper bound for the Wassertein-p distance for locally dependent random variables and strongly mixing stationary random fields. Our proofs adapt the Stein dependency neighborhood method to the Wassertein-p distance and as a by-product we establish high-order local expansions of the Stein equation for dependent random variables. Finally, we demonstrate how our results can be used to obtain tail bounds that are asymptotically tight, and decrease polynomially fast, for the empirical average of weakly dependent random variables.

Inducing high spatial correlation with randomly edge-weighted neighborhood graphs.

Rosangela Helena Loschi

Departamento de Estatística - Universidade Federal de Minas Gerais

Traditional models for areal data assume a hierarchical structure where one of the components is the random effects that spatially correlate the areas. The conditional autoregressive (CAR) model is the most popular distribution to jointly model the prior uncertainty about these spatial random effects. One limitation of the CAR distribution is the inability of producing high correlations between neighboring areas. We propose a new model for areal data that alleviates this problem. We represent the map by an undirected graph where the nodes are the areas and randomly-weighted edges connect nodes that are neighbors. The model is based on

a multivariate Student-t distribution, spatially structured, in which the precision matrix is indirectly built assuming a multivariate distribution for the random edges effects. The edges effects' joint distribution is a spatial multivariate Student-t that induces another t distribution for the areas' spatial effects which inherit its capacity to accommodate outliers and heavy-tail behavior. Most important, it can produce a higher marginal correlation between the spatial effects than the CAR model overcoming one of the main limitations to this model. We fit the proposed model to analyze real cancer maps and compared its performance with several state-of-art competitors. Our proposed model provides better fitting in almost all cases. Joint work with Danna L. Cruz and Renato M. Assunção

Funding: This work was supported by Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) Fundação de Amparo à Pesquisa do Estado de Minas Gerais FAPEMIG.

Dimensionless machine learning: Enforcing exact units equivariance

Soledad Villar

Johns Hopkins University

Units equivariance (or units covariance) is the exact symmetry that follows from the requirement that relationships among measured quantities of physics relevance must obey self-consistent dimensional scalings. Here, we express this symmetry in terms of a (non-compact) group action, and we employ dimensional analysis and ideas from equivariant machine learning to provide a methodology for exactly units-equivariant machine learning: For any given learning task, we first construct a dimensionless version of its inputs using classic results from dimensional analysis, and then perform inference in the dimensionless space. Our approach can be used to impose units equivariance across a broad range of machine learning methods which are equivariant to rotations and other groups. We discuss the in-sample and out-of-sample prediction accuracy gains one can obtain in contexts like symbolic regression and emulation, where symmetry is important. We illustrate our approach with simple numerical examples involving dynamical systems in physics and ecology.

The extrapolation of correlation

Victor Panaretos

Institute of Mathematics, EPFL

We discuss the problem of positive-semidefinite extension: extending a partially specified covariance kernel from a subdomain Ω of a rectangular domain $I \times I$ to a covariance kernel on the entire domain $I \times I$. For a broad class of domains Ω called serrated domains, we present a complete theory. Namely, we demonstrate that a canonical completion always exists and can be explicitly constructed. We characterise all possible completions as suitable perturbations of the canonical completion, and determine necessary and sufficient conditions for a unique completion to exist. We interpret the canonical completion via the graphical model structure it induces on the associated Gaussian process. Furthermore, we show how the determination of the canonical completion reduces to the solution of a system of linear inverse problems in the space of Hilbert-Schmidt operators, and derive rates of convergence when the kernel is to be empirically estimated. We conclude by providing extensions of our theory to more general forms of domains, and by demonstrating how our results can be used in statistical inverse problems associated with stochastic processes. Based on joint work in collaboration with K.G. Waghmare (EPFL)

Invited Thematic Sessions

Robustness

Organizer: **Graciela Boente**, Universidad de Buenos Aires

Simultaneous robust estimation and variable selection for partially linear additive models

Alejandra Mercedes Martínez

Universidad Nacional de Luján and CONICET

In partially linear additive models the response variable depends linearly on some covariates while the others enter as a sum of univariate functions. In practice, a large number of covariates may be collected and the non-significative ones should be excluded.

In order to obtain simultaneously robust estimators and select the active covariates, we introduce robust estimators that combines $B-$splines, robust regression estimators and a regularization procedure based on a SCAD penalty. Through simulations, we will show the advantages of the proposed methodology with the least squares-based one. Finally, we will also illustrate the robust proposal on a real data set.

Addressing robust estimation in conditional ROC curves

Ana M. Bianco

Instituto de Calculo, Universidad de Buenos Aires and CONICET

Receiver Operating Characteristic (ROC) curves are a graphical tool useful to analyse the accuracy of a given assignment rule. In this sense, given a binary classifier, the corresponding ROC curve offers a general perspective of the capability of the classifier to discriminate between two different groups.

The discriminatory effectiveness of the marker under study may be affected by several factors. When this information is registered in suitable covariates, it is sensible to include them in order to improve the ROC analysis.

In this talk we will focus on ROC curves in presence of covariates and we will address both, the induced ad direct methods. We will show the instability of the conditional ROC curve when there are outliers and we will introduce robust proposals for both methods. Our approach is semiparametric and combines robust estimators of regression models with weighted empirical distribution estimators based on an adaptive procedure that down–weights outliers.

We will discuss some theoretical aspects and through a Monte Carlo study we will compare the performance of the proposed estimators with the classical ones both, in clean and contaminated samples. We will illustrate our approach through the analysis of a real data set.

Network estimation problems

Organizer: **Oscar Madrid Padilla**, University of California

---

Joint spectral clustering in multilayer networks

Jesús Arroyo

Department of Statistics, Texas A&M University

Modern network datasets are often composed of multiple layers. These data require flexible and tractable models and methods capable of aggregating information across the networks. To that end, this talk considers the community detection problem under the multilayer degree-corrected stochastic blockmodel. We propose a spectral clustering algorithm and demonstrate that its misclustering error rate improves exponentially with multiple network realizations, even in the presence of significant layer heterogeneity. The methodology is illustrated in a case study of US airport data, where we identify meaningful community structure and trends influenced by pandemic impacts on travel. This is joint work with Joshua Agterberg and Zachary Lubberts.

Robust spectral clustering with rank statistics

Joshua Cape

University of Wisconsin–Madison, USA

Traditional non-robust approaches for spectral clustering and embedding exhibit severe performance degradation in the presence of outliers, heavy-tailed distributions, and heterogeneous noise variances. In this talk, we address these challenges by studying the problem of robust spectral clustering using rank statistics. We highlight ongoing work spanning methodology, theory, and applications, with a focus on statistical guarantees for user-friendly dimensionality reduction techniques.

Learning Gaussian DAGs from Network Data

Oscar Hernan Madrid Padilla

University of California, Los Angeles

Structural learning of directed acyclic graphs (DAGs) or Bayesian networks has been studied extensively under the assumption that data are independent. We propose a new Gaussian DAG model for dependent data which assumes the observations are correlated according to an undirected network. Under this model, we develop a method to estimate the DAG structure given a topological ordering of the nodes. The proposed method jointly estimates the Bayesian network and the correlations among observations by optimizing a scoring function based on penalized likelihood. We show that under some mild conditions, the proposed method produces consistent estimators after one iteration. Extensive numerical experiments also demonstrate that by jointly estimating the DAG structure and the sample correlation, our method achieves much higher accuracy in structure learning. When the node ordering is unknown, through experiments on synthetic and real data, we show that our algorithm can be used to estimate the correlations between samples, with which we can decorrelate the dependent data to significantly improve the performance of classical DAG learning methods.

Dependent Structures in Network Data

Sharmodeep Bhattacharyya

Oregon State University

Statistical analysis of networks generated from exchangeable network models has been extensively studied in the literature. We extend the framework of network formation to include dependent edges with an emphasis on generating networks with all five properties of sparsity, small-world, community structure, power-law degree distribution, and transitivity or high triangle count. We propose a class of models called Transitive Inhomogeneous Erdos-Renyi (TIER) models, which we show have all five properties. We also perform inferential tasks, such as parameter estimation, community detection, and change-point detection for sequences of dependent networks from Inhomogeneous Erdos-Renyi (IER) and TIER models. We validate our results using simulation studies too. If time permits, we will talk about temporal network modeling using point process and network models and some recent developments in the estimation of the number of communities using Bethe Hessian matrices.

Random geometry

Organizer: **Avelio Sepúlveda**, Universidad de Chile

Interplay between the GFF and the O(N) model

Avelio Sepúlveda

Departamento de Ingeniería matemática, Universidad de Chile

Joint work with Juhan Aru and Christophe Garban. In this presentation, we will discuss the 2-point correlation of the $O(3)$ model. Following ideas of Patrascioiu and Seiler, we express this correlation function as constant times the probability that both points belong to the same connected component of a percolation model. Using this idea, we confirm the fact that if the complement of this percolation model does not percolate, the two-point correlation function of the $O(3)$-model does not decrease exponentially with the distance. However, we explain how there can be exponential decorrelation in the case where the model does percolate. We do this by constructing an XY-model in a random environment where the temperature is low everywhere but in a small non-percolative set and where the 2-point correlation function decreases exponentially. It is instrumental for all of these results to understand the relationship between the $O(N)$-model and the Gaussian free field.

Historical lattice trees

Manuel Cabezas

Universidad Católica de Chile

In this talk I will briefly introduce the model of lattice trees and recall the main theorems about their asymptotic behavior in high dimensions. I will also present a new result concerning their convergence to the Super Brownian motion in the Historical sense in the high dimensional setting. This is joint work with A. Fribergh, M. Holmes and E. Perkins.

Funding: This work was supported by Fondecyt regular 1201090

On the chemical distance of random interlacements

Saraí Hernández-Torres

Instituto de Matemáticas, UNAM

Random interlacements is a Poissonian soup of doubly-infinite random walk trajectories on $\mathbb{Z}^d$, with a parameter $u > 0$ controlling the intensity of the Poisson point process. We consider the time constant ρ_u associated with the chemical distance in random interlacements. It is conjectured that $c_d\sqrt{u}\rho_u$ converges to the Euclidean norm as $u \downarrow 0$. This talk presents advancements on this conjecture when $d \geq 5$: we prove a sharp upper bound and an almost sharp lower bound for the time constant as the intensity decays to zero.

Joint work with Eviatar Procaccia and Ron Rosenthal.

Funding: This work was supported by ISF grant 1692/17, BSF Grant 2018330, NSF Grant DMS-1812009 and ISF grant 771/17.

References:

1. Hernández-Torres, S., Procaccia, E.B. and Rosenthal, R.: *The Chemical Distance in Random Interlacements in the Low-Intensity Regime*, Commun. Math. Phys. (2023).

Stochastic models in biology

Organizer: **Noemi Kurt**, Goethe Universität

The evolution and the genealogy of a self-similar population

Arno Siri-Jégousse

UNAM, Mexico City

In this talk we will study Markovian measure-valued processes as population models. A Lamperti-Kiu transform can be obtained for such processes, transforming them into Markov Additive processes (MAP) via a random time change, where the first coordinate is a Lévy process representing the logarithm of the total size, and the second coordinate is a probability-valued process representing the evolution of the renormalized population. In particular, we will focus on the special case where the second coordinate is a Λ-Fleming-Viot process, dual to the Λ-coalescent. This result generalizes and sheds a new light to celebrated connections between stable branching processes and Beta-coalescents established in [1]. This is a joint work with Alejandro H. Wences (University of Toulouse).

References:

1. Birkner, M., Blath, J., Capaldo, M., Etheridge, A., Möhle, M., Schweinsberg, J. and Wakolbinger, A.: *Alpha-stable branching and beta-coalescents*, Electronic Jornal of Probability, 303–325 (2005).

Invasion of cooperative parasites in structured host populations

Cornelia Pokalyuk

ENS Lyon

Certain defense mechanisms of phages against the immune system of their bacterial host rely on cooperation of phages. Motivated by this example we analysed in [1] the spread of cooperative parasites in host populations that were structured according to a configuration model. Building on these results we consider the case of a host population which is (genuinely spatially) structured according to a random geometric graph. We identify the spatial scale at which invasion of parasites turns from being an unlikely to a highly probable event and give in the critical regime upper and lower bounds on the invasion probability. This talk is based on joint work (partially in progress) with Vianney Brouard and Marco Seiler.

References:

1. V. Brouard and C. Pokalyuk., Invasion of parasites in moderately structured host populations, Stoch. Proc. Appl., **153**, pp 221-263 (2022)

Λ-Wright–Fisher processes with selection and opposing environmental effects

Fernando Cordero

Bielefeld University

Moment duality has proven to be a powerful tool for the analysis of Λ-Wright–Fisher processes under special forms of selection. In the first part of the talk, I will briefly explain how to use moment duality to characterize the long-term behaviour of the process, but also what limitations this method has. In the second part, I will describe a new approach based on Siegmund duality, which allows us to determine the long-term behaviour of Λ-Wright–Fisher processes under fairly general forms of selection and environmental effects. This analysis will reveal a class of stochastic population models in which, selection alone maintains coexistence.

This is joint work with Sebastian Hummel and Grégoire Véchambre, see [1].

Funding: F. Cordero is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 317210226 – SFB 1283. S. Hummel is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Projektnummer 449823447; he is also partially supported by BEAR grants from the University of California at Berkeley. G. Véchambre is funded by NSFC grant No. 11688101.

References:

1. Cordero, Fernando and Hummel, Sebastian and Véchambre, Grégoire: *Λ-Wright–Fisher processes with general selection and opposing environmental effects: fixation and coexistence*, eprint: arXiv:2112.10560.

Interacting Poissonian trajectories and clonal interference

Renato S. dos Santos

UFMG

We consider a Moran model with mutation and selection in the limit of large population. Mutation occurs in the so-called Gerrish-Lenski regime where mutations are neither too frequent nor too rare, giving rise to clonal interference. Focusing on the case of strong selection, we show distributional convergence of the rescaled process to a system of interacting Poissonian lines. This is a joint work with Adrián González-Casanova, Felix Hermann, András Tóbiás and Anton Wakolbinger.

Acknowlegments: I thank the Pró-Reitoria de Pesquisa da Universidade Federal de Minas Gerais.

Funding: This work was partially supported by CNPq grants 313921/2020-2 and 406001/2021-9, and FAPEMIG grants APQ-02288- 21 and RED-00133-21.

Stochastic processes

Organizer: **Pablo Groisman**, Universidad de Buenos Aires

Scaling Limit for the Cover Time of the Binary Tree

Santiago Saglietti

Pontificia Universidad Católica de Chile

We consider a continuous time random walk on the rooted binary tree of depth n with all transition rates equal to one and study its cover time, i.e., the time it takes the walk to visit all the vertices of the graph. We prove that, normalized by $2^{n+1}n$ and then centered by $(log 2)n - log n$, the cover time admits a weak limit as the depth of the tree tends to infinity. The limiting distribution is identified as that of a randomly shifted Gumbel random variable, where the shift is explicitly characterized in terms of a certain derivative martingale associated with the problem. The existence of the limit and its overall form were already conjectured in the literature. However, our approach is quite different from those taken in earlier works on the subject and relies in great part on understanding the properties of the maximum of a specific branching random walk associated with the problem. Joint work with Aser Cortines and Oren Louidor.

Random walk on the simple symmetric exclusion process

Daniel Kious

In this talk, I will cover two works in collaboration with Marcelo Hilário and Augusto Teixeira, and with Guillaume Conchon-Kerjan and Pierre-François Rodriguez. We investigate the long-term behavior of a random walker evolving on top of the simple symmetric exclusion process (SSEP) at equilibrium. At each jump, the random walker is subject to a drift that depends on whether it is sitting on top of a particle or a hole. The asymptotic behavior is expected to depend on the density ρ in $[0, 1]$ of the underlying SSEP.
Two of the papers above imlpy a law of large numbers (LLN) for the random walker for all densities ρ except at most one value ρ_0, where the speed (as a function of the

density) possibly jumps over 0.
Second, we prove that, for any density corresponding to a non-zero speed regime, the fluctuations are diffusive and a Central Limit Theorem holds.
I will also mention a joint work with with Rangel Baldasso, Marcelo Hilário and Augusto Teixeira, where we investigate the fluctuations of this model in the zero-speed regime, for an environment with better mixing properties.

Oriented percolation with modified boundaries

Leonardo T. Rolla

University of São Paulo

Monotonicity questions in oriented percolation and contact process are more tricky than we may think, and nothing similar to enhanced percolation arguments seem to work. For example, it is immediate that the critical parameter of the contact process is monotone in the dimension, but there is so far no proof that it is strictly monotone. In this talk, we consider two-dimensional directed percolation (or one-dimensional contact process) with two parameters: infection from the leftmost and rightmost occupied sites towards the exterior occurs at a different rate than in the interior. We show that the critical curve on the parameter space is strictly decreasing. In particular, any subcritical choice for the external parameter causes the critical internal parameter to increase strictly. In this regime, the process is still attractive but no longer additive, and most of the classical arguments break down. We also show that any supercritical choice for the external parameter makes the process percolate even if the internal parameter is critical (in this regime, the process is not attractive). Joint work with Enrique Andjel.

Statistical theory for neural networks

Organizer: **Johannes Schmidt-Hieber**, University of Twente

A survey of statistical theory for deep learning

Johannes Schmidt-Hieber

University of Twente

Recently a lot of progress has been made regarding the theoretical understanding of deep neural networks. One of the very promising directions is the statistical approach, which interprets machine learning as a collection of statistical methods and builds on existing techniques in mathematical statistics to derive theoretical error bounds and to understand phenomena such as overparametrization. The talk surveys this field and describes future challenges.

Dropout in the Linear Model

Sophie Langer

University of Twente

Dropout is a technique to prevent neural networks from overfitting. By randomly dropping neurons in each training step, it can be seen as an algorithmic regularization technique, that has proven effectiveness in various applications. Most theoretical results link dropout with explicit regularization. In case of linear models the relation to ℓ_2-penalization was stated. In this talk we investigate the explicit behavior of the iterates generated by gradient descent with dropout in a linear model. We present two different ways of applying dropout in the training procedure. First, by taking the gradient of a model reduced by dropout. Second, by taking the gradient of the full model and then reducing it by dropout. In the first, more complex, case we show that in expectation the iterates converge to a ℓ_2-regularized estimator, while the sequence of variances does not converge to its explicit counterpart. In the second case the convergence of the iterates to the linear least squares estimator is shown. Our analysis is explicit, stating convergence rates, that depend on the input, the learning rate, the initalization point and the dropout probability.
This talk is based on joint work with Gabriel Clara and Johannes Schmidt-Hieber.

On Generalization Bounds for Deep Networks based on Loss Surface Implicit Regularization

Masaaki Imaizumi

The University of Tokyo

The classical statistical learning theory implies that fitting too many parameters leads to overfitting and poor performance. That modern deep neural networks generalize well despite a large number of parameters contradicts this finding and constitutes a major unsolved problem towards explaining the success of deep learning. While previous work focuses on the implicit regularization induced by stochastic gradient descent (SGD), we study here how the local geometry of the energy landscape around local minima affects the statistical properties of SGD with Gaussian gradient noise. We argue that under reasonable assumptions, the local geometry forces SGD to stay close to a low dimensional subspace and that this induces another form of implicit regularization and results in tighter bounds on the generalization error for deep neural networks. To derive generalization error bounds for neural networks, we first introduce a notion of stagnation sets around the local minima and impose a local essential convexity property of the population risk. Under these conditions, lower bounds for SGD to remain in these stagnation sets are derived. If stagnation occurs, we derive a bound on the generalization error of deep neural networks involving the spectral norms of the weight matrices but not the number of network parameters. Technically, our proofs are based on controlling the change of parameter values in the SGD iterates and local uniform convergence of the empirical loss functions based on the entropy of suitable neighborhoods around local minima. This is a joint work with Johannes Schmidt-Hieber.

Funding: Masaaki Imaizumi received support from JSPS KAKENHI (18K18114) and JST Presto (JPMJPR1852).

References

1. Masaaki, Imaizumi and Johannes, Schmidt-Hieber: *On Generalization Bounds for Deep Networks based on Loss Surface Implicit Regularization*, IEEE Transaction on Information Theory, to appear.

Strongly correlated particle systems

Organizer: **Alexandre Stauffer**, University of Bath

Smoothness of the diffusion coefficients for particle systems in continuous space

Maximilian Nitzschner

NYU Courant Institute of Mathematical Sciences

We consider a class of particle systems with local interactions in continuous space, which are reversible with respect to the Poisson measures with constant density. A natural quantity of interest capturing the large-scale behavior of particles in this set-up is the bulk diffusion matrix. Recent work by Giunti, Gu, and Mourrat has established that finite-volume approximations of this diffusion matrix converge at an algebraic rate. We show that the bulk diffusion matrix is an infinitely differentiable function of the density of particles, and obtain relatively explicit expressions for the derivatives in terms of the corrector, an object which already appeared in the description of the bulk diffusion matrix itself.

Based on joint work with Giunti, Gu, and Mourrat.

References:

1. A. Giunti, C. Gu, J.-C. Mourrat, and M. Nitzschner: *Smoothness of the Diffusion Coefficients for Particle Systems in Continuous Space*, to appear in Commun. Contemp. Math., https://doi.org/10.1142/S0219199722500274 (2022).

The gradient squared of the Gaussian free field

Alessandra Cipriani

University College London

In this talk we study the scaling limit of a random field which is a non-linear transformation of the gradient discrete Gaussian free field (DGFF). More precisely, our object of interest is the recentered square of the norm of the gradient DGFF at every point of the square lattice. Surprisingly, in dimension 2 this field bears a very close connection to the height-one field of the Abelian sandpile model studied in Dürre (2009). In particular we wonder whether its scaling limit equals that of the height-one field. We will give a partially incorrect answer (that is, off by a constant) and will explain why the introduction of the fermionic Gaussian free field changes the picture. This talk is based on ongoing joint works with Leandro Chiarini Medeiros, Rajat Subhra Hazra, Alan Rapoport, Wioletta Ruszel.

The monotonic speed of the random walk on the simple exclusion process

Guillaume Conchon--Kerjan

University of Bath

The random walk on the simple exclusion process (SEP) on the d-dimensional lattice has attracted considerable attention in the last decade. In this model, a random walker moves at each time unit to a neighbouring position, with a drift that depends on whether its location is occupied or not by the SEP. In dimension 1, if occupied (resp. empty) sites have a drift to the right (resp. to the left), then when the density of the SEP is large (resp. small) enough, the random walk has a positive (resp. negative) speed. But could it be that for some non-empty interval of densities, the random walk has zero speed (which is the case in some static i.i.d. environments)? We show that the speed is strictly increasing, and hence can be zero for at most one

density. We use coupling methods that take advantage of the mixing properties of the SEP. This is a joint work with Daniel Kious (University of Bath) and Pierre-François Rodriguez (Imperial College).

Random walks driven by interacting particle systems in one dimension

Marcelo R. Hilário

Universidade Federal de Minas Gerais

In this talk we review some recent developments in the study of random walks in dynamic random environments via multiscale renormalization techniques. We consider the case when the environment is given by interaction particle systems such as the simple symmetric exclusion process and the zero-range process. Our main results are laws of large numbers for the displacements of the walk and, in some ballistic cases, central limits theorems.

Acknowlegments: I thank Weberson Arcanjo, Rangel Baldasso, Oriane Blondel, Frank den Hollander, Renato dos Santos, Vladas Sidoravicius and Augusto Teixeira with whom we have obtained the several results presented.

Funding: This work was supported by CNPq and FAPEMIG

Random graphs and trees

Organizer: **Louigi Addario-Berry**, McGill University

Weight distribution of Minimal Spanning Acycles

Nicolas Fraiman

University of North Carolina at Chapel Hill

In this talk, we look at the distribution of weights in the random Minimum Spanning Acycle (MSA). A classic result by Frieze [1] is that the total weight of the minimum spanning tree (MST) of the uniformly weighted graph converges to zeta(3). Recently, this result was extended to a uniformly weighted simplicial complex [2], where the role of the MST is played by the MSA, its higher-dimensional analogue. We study

the bulk and extremes of the weights in the MSA. We show that the rescaled empirical distribution of weights converges to a measure based on the density of the shadow (an object that is used to generalize the giant component to higher dimensions). We also show that the shifted extremal weights converge to an inhomogeneous Poisson point process. This is joint work with Sayan Mukherjee and Gugan Thoppe.

References:

1. Frieze, Alan: *On the value of a random minimum spanning tree problem*, Discrete Applied Mathematics, 10(1), 47–56 (1985).
2. Hino, Masanori and Kanazawa, Shu: *Asymptotic behavior of lifetime sums for random simplicial complex processes*, Journal of the Mathematical Society of Japan, 71(3), 765–804 (2019).

Opinion dynamics on directed complex networks

Mariana Olvera-Cravioto

University of North Carolina, Chapel Hill

We study a general version of the classical DeGroot-Friedkin model on sparse random digraphs whose local weak limit is a marked Galton-Watson process. This model has been extensively used in the social sciences to study opinion dynamics on social networks. The type of graphs in our analysis include the directed versions of the Erdos-Renyi graph, the Chung-Lu model, the Norros-Reittu model, and the configuration model, among others. We show that the stationary distribution of a typical vertex in the graph converges in distribution to a random variable that can be constructed on the limiting tree. Furthermore, our approach allows us to provide exact formulas for the mean and variance of the limiting stationary distribution, which can be used to characterize the conditions that lead to either "consensus" or "polarization". In particular, we explain how cognitive biases and the presence of stubborn agents (vertices that cannot be influenced) have on the evolution of opinions, in some cases promoting polarization and in others reducing it.

The triviality of the shocked map

Avelio Sepúlveda

Departamento de Ingeniería matemática, Universidad de Chile

Joint work with Luis Fredes. A (non-spanning) tree-decorated map is a random pair form by a quadrangulation and a subtree chosen uniformly over the set of pairs

with prescribed size. One can do a bijection from this object towards an independent pair of a tree and a map with a boundary. In this talk, I will discuss this bijection and use it to study the critical regime: when the size of the map, f, is proportional to the square of the size of the tree. In particular, we will see that in that regime the diameter of the tree is between $o(f^{1/4})$ and $f^{1/4}/\log^{\alpha}(f)$, for $\alpha > 1$. Thus after scaling the distances by $f^{-1/4}$, the critical tree-decorated quadrangulation converges to a Brownian disk where the boundary has been identified to a point.

TBA

Simon Griffiths

PUC-Rio

TBA

Branching Processes

Organizer: **Santiago Saglietti**, Pontificia Universidad Católica de Chile

---

Evolving genealogies for finite branching populations under selection and competition

Airam Blancas

ITAM

In this talk we present a lookdown and a branching particle system version of a finite population evolving with time. Individuals have one of two types and the population dynamics include selection and competition. The population size varies with time. In both models, we record genealogical distances between as well as the types of all individuals. As we will explain, these two version result in different processes for the marked metric spaces, but in the same process for their equivalence classes. In [1], we have a look at the infinite population limit. Based on a joint work with S. Gufler, S. Kliem, V. C. Tran and A. Wakolbinger.

References:

1. Blancas, A., Gufler, S., Kliem, S., Tran, V. C. and Wakolbinger, A.: *Evolving genealogies for finite branching populations under selection and competition*, To appear in Annals of Applied Probability (2023).

The Kuramoto Model in Random Dynamical Graphs

Pablo Groisman

University of Buenos Aires

We will discuss a Kuramoto model of coupled oscillators on a time-varying graph, whose dynamics is dictated by a Markov process in the space of graphs. The simplest representative is considering a base graph and then the subgraph determined by N independent random walks on the underlying graph. We prove a synchronization result for solutions starting from a phase-cohesive set independent of the speed of the random walkers, an averaging principle and a global synchronization result with high probability for sufficiently fast processes. We will also consider Kuramoto oscillators in a dynamical version of the Random Conductance Model.

Modern martingale methods in machine learning and statistics

Organizer: **Aaditya Ramdas**, Carnegie Mellon University

Testing exchangeability: fork-convexity, supermartingales, and e-processes

Johannes Ruf

LSE

Suppose we observe an infinite series of coin flips X1, X2, ..., and wish to sequentially test the null that these binary random variables are exchangeable. Nonnegative supermartingales (NSMs) are a workhorse of sequential inference, but we prove that they are powerless for this problem. First, utilizing a geometric concept called fork-convexity (a sequential analog of convexity), we show that any process that is an NSM under a set of distributions, is also necessarily an NSM under their "fork-convex hull". Second, we demonstrate that the fork-convex hull of the exchangeable null consists of all possible laws over binary sequences; this implies that any NSM under exchangeability is necessarily nonincreasing. Since testing arbitrary deviations from exchangeability is information-theoretically impossible, we focus on Markovian alternatives. We combine ideas from universal inference and the method of mixtures to derive a "safe e-process", which is a nonnegative process with expectation at most one under the null at any stopping time, and is upper bounded by a martingale, but is not itself an NSM.

Joint work with Wouter Koolen, Martin Larson, Aaditya Ramdas

Assessing the calibration of multivariate probabilistic forecasts: Sequential tests using e-values

Sam Allen

University of Bern

When evaluating probabilistic forecasts, calibration refers to the statistical consistency between forecasts and the corresponding outcomes. In this work, we introduce a general definition of calibration for multivariate forecasts, and demonstrate how multivariate forecast calibration can be tested sequentially using e-values. E-values are non-negative random variables with expectation at most one under the null hypothesis, and they can be combined to form a test martingale that is suitable for hypothesis testing in sequential settings. To illustrate this in practice, e-values are used to sequentially assess the calibration of probabilistic forecasts for spatial weather fields.

Acknowlegments: This work was performed in collaboration with Johanna Ziegel.

Funding: This work was supported by the Swiss Federal Office of Meteorology and Climatology (MeteoSwiss) and the Oeschger Centre for Climate Change Research.

Applications of Martingale Statistical Methods at Netflix

Michael Lindon

Netflix

Experimentation is fundamental to how Netflix operates as a company. Innovations to the product, changes to production code, and deployment of new applications and infrastructure are all rigorously A/B tested. Doing this at scale, however, poses unique challenges. The sheer volume of users in these experiments means it is easy to rapidly incur large regret if treatment effects are negative. Performing large numbers of experiments at scale also requires a great deal of automation. For these reasons, Netflix employs sequential statistical methodologies that allow experiments to be

continuously monitored. These methodologies which provide time-uniform Type I error and coverage guarantees are fundamentally based on martingales. This talk will survey a number of applications at Netflix. Sequential tests for differences in time inhomogeneous Poisson point processes are used to monitor error rates when pushing new code to production. Sequential tests for differences in arbitrary collections of quantiles are used to test for performance regressions in latency and round trip time when deploying new applications and infrastructure. Confidence sequences for estimation of average treatment effects are used in experiments on the user interface. Confidence sequences for in-sample causal estimates are used in multi-armed bandit and continuous explore exploit systems for title images and synopses.

Funding: Netflix

References

1. Lindon, Michael and Malek, Alan: *Anytime Valid Inference for Multinomial Count Data*, Advances in Neural Information Processing Systems (2022).

2. Lindon, Michael and Sanden, Chris and Shirikian, Vache: *Rapid Regression Detection in Software Deployments through Sequential Testing*, Proceedings of the 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (2022)

3. Lindon, Michael and Ham,Dae Woong and Tingley, Martin and Bojinov, Iavor : *Anytime-Valid F-Tests for Faster Sequential Experimentation Through Covariate Adjustment*, ArXiV (2022)

4. Ham,Dae Woong and Bojinov, Iavor and Lindon, Michael and Tingley, Martin : *Design-Based Confidence Sequences for Anytime-valid Causal Inference*, ArXiV (2022)

Contributed Thematic Sessions

Probabilistic and statistical aspects of data privacy

Organizer: **Mario Diaz**, IIMAS - UNAM

Local Differential Privacy From the Lens of Contraction of Markov Kernels

Shahab Asoodeh

McMaster University

In this talk, we focus on the local model of differential privacy, where unlike the central model, the user (i.e., data owner) randomizes their data before releasing it to the analyst. Since the private data remains at the hand of users, this model of data privacy is popular and has been implemented in Google, Apple, Microsoft and several other tech companies.

We show that a Markov kernel (aka mechanism) is locally differentially private if and only if its contraction coefficient under a certain f-divergence is equal to zero. The f-divergence in this result is the so-called hockey-stick divergence which is known to have a very interesting property: all f-divergences with twice differentiable f can be expressed by the hockey-stick divergence. This therefore enables us to study local differential privacy using rich properties of f-divergences. For instance, we discuss mean estimation in Gaussian location model and density estimation under local differential privacy using the relationship between hockey-stick divergence and χ^2-divergence.

This talk is based on joint work with Huanyu Zheng, Mario Diaz, Maryam Aliakbarpour, and Flavio Calmon [1,2,3].

Funding: This work was supported by Natural Sciences and Engineering Research Council of Canada.

References

1. Asoodeh, Shahab and Zheng, Huanyu: *Contraction of Locally Differentially Private Mechanisms*, arXiv:2210.13386, 2023.
2. Asoodeh, Shahab, Diaz, Mario and Calmon, Flavio *Privacy Analysis of Online Learning Algorithms via Contraction Coefficients*, arXiv:2012.11035, 2022
3. Asoodeh, Shahab, Aliakbarpour, Maryam and Calmon, Flavio *Local Differential Privacy Is Equivalent to Contraction of an f-Divergence*, IEEE International Symposium on Information Theory (ISIT), 2021.

A brief introduction to differential privacy

Mario Diaz

IIMAS - UNAM

In this talk we introduce some basic aspects of differential privacy and some of its variations. Specifically, we discuss their operational interpretations, formulations in terms of statistical divergences, and connections to hypothesis testing. This talk is intended to serve as a brief introduction for the rest of the talks of the session.

Differentially private inference via noisy optimization

Marco Avella Medina

Columbia University

We propose a general optimization-based framework for computing differentially private M-estimators and a new method for the construction of differentially private confidence regions. Firstly, we show that robust statistics can be used in conjunction with noisy gradient descent and noisy Newton methods in order to obtain optimal private estimators with global linear or quadratic convergence, respectively. We establish global convergence guarantees, under both local strong convexity and self-concordance, showing that our private estimators converge with high probability to a neighborhood of the non-private M-estimators. The radius of this neighborhood is nearly optimal in the sense it corresponds to the statistical minimax cost of differential privacy up to a logarithmic term. Secondly, we tackle the problem of parametric inference by constructing differentially private estimators of the asymptotic variance of our private M-estimators. This naturally leads to the use of approximate pivotal statistics for the construction of confidence regions and hypothesis testing. We demonstrate the effectiveness of a bias correction that leads to enhanced small-sample empirical performance in simulations.

This is joint work with Casey Bradshaw and Po-Ling Loh.

The Saddle-Point Accountant for Differential Privacy

Prof. Flavio du Pin Calmon

Harvard John A. Paulson School of Engineering And Applied Sciences

In this talk we characterize the differential privacy guarantees of privacy mechanisms in the large-composition regime, i.e., when a privacy mechanism is sequentially applied a large number of times to sensitive data. Via exponentially tilting the privacy loss random variable, we derive a new formula for the privacy curve expressing it as a contour integral over an integration path that runs parallel to the imaginary axis with a free real-axis intercept. Then, using the method of steepest descent from mathematical physics, we demonstrate that the choice of *saddle-point* as the real-axis intercept yields closed-form accurate approximations of the desired contour integral. This procedure—dubbed the saddle-point accountant (SPA)—yields a constant-time accurate approximation of the privacy curve. Theoretically, our results can be viewed as a refinement of both Gaussian Differential Privacy and the moments accountant method found in Rényi Differential Privacy. In practice, we demonstrate through numerical experiments that the SPA provides a precise approximation of privacy guarantees competitive with purely numerical-based methods (such as FFT-based accountants), while enjoying closed-form mathematical expressions.

Acknowlegments: Joint work with Wael Alghamdi (Harvard University), Prof. Shahab Asoodeh (McMaster University), Juan Felipe Gomez (Harvard University), Prof. Oliver Kosut (Arizona State University), and Prof. Lalitha Sankar (Arizona State University)

Funding: This work was supported by the National Science Foundation under Grant CIF-1900750.

Stochastic Differential Equations and Applications

Organizer: **Soledad Torres**, Universidad de Valparaíso

A method for long-term integration of second-order Langevin-type stochastic differential equations

Hugo de la Cruz

School of Applied Mathematics. FGV EMAp. Brazil

We devise a method for the long-term integration of a class of damped second-order stochastic differential systems. The introduced numerical scheme has the advantage of being completely explicit for general nonlinear systems while, in contrast with other commonly used integrators, it is able to compute the evolution of the system with high stability and precision in very large time intervals. Notably, the method has the important property of preserving, for all values of the step-size, the steady-state probability density function of any linear system with a stationary distribution. Numerical experiments are presented to illustrate the practical performance of the introduced method.

Sufficient variability of paths and differential equations with BV-coefficients

Lauri Viitasaari

Uppsala University

Partial differential equations and differential systems play a fundamental role in many aspects of our daily life. However, in stochastic versions the underlying equation does not make sense in a classical way and one has to consider integral equations instead. Moreover, even the concept of integral is subtle for $\int_0^t \varphi(X_s)\, dY_s$, where φ is a given function and X, Y are non-differentiable objects. Several powerful techniques such as rough path theory have emerged to treat these situations, and it can be safely stated that nowadays differential systems driven by rough signals are already rather well understood. The idea in the rough path theory is, roughly speaking, that one assumes additional smoothness on the function φ in order to compensate bad behaviour of signal functions X and Y. As such, the methodology cannot be applied in any straightforward manner if one allows discontinuities in φ. In particular, this is the case if φ is a general BV-function.
In this talk we combine tools from fractional calculus and harmonic analysis to some fine properties of BV-functions and maximal functions, allowing us to give a meaningful definition for (multidimensional) integrals $\int_0^t \varphi(X_s)\, dY_s$ with a BV-function φ, provided that the functions X and Y are regular enough in the Sobolev sense. Here enough regularity means better regularity than what is customary assumed in the rough path theory, and this gain in regularity can be used to compensate ill behaviour of φ. The key idea is that the signal X should not spend too much time, in some sense, on the bad regions of φ. We quantify this in terms of potential theory and Riesz energies. We also discuss several consequences, and provide existence and uniqueness results for certain differential systems involving BV-coefficients. Extensions and further topics are discussed.

The talk is based on a joint work with Michael Hinz (Bielefeld University) and Jonas Tölle (Aalto University) [1,2].

References:

1. Hinz, M., Tölle, J., and Viitasaari, L.: *Variability of paths and differential equations with BV-coefficients*, Accepted for publication in Ann. Inst. H. Poincaré Probab. Statist. (2023)

2. Hinz, M., Tölle, J., and Viitasaari, L.: *Sobolev regularity of occupation measures and paths, variability and compositions*, Electronic Journal of Probability, 27(73): 1–29. (2022)

Diffusions in Graphs: construction and optimal stopping problems

Ernesto Mordecki

Centro de Matemática, Facultad de Ciencias, Universidad de la República, Uruguay

The purpose of the talk is twofold. We first revise the construction of diffusions over metric graphs. Although this is considered a well-understood topic, a good reference to a detailed construction in the framework of the Hille-Yosida approach is difficult to find. Second, we pose the optimal stopping problem for a particle that moves as a diffusion on a graph. We show a solution to this problem when the underlying graph is a star (i.e. the so-called Spider diffusion) and then discuss the stopping problem in a general graph.
This is joint work with Jukka Lempa and Paavo Salminen [1].

References:

1. Lempa, Jukka and Mordecki Ernesto and Salminen Paavo: *Diffusion spiders: Green kernel, excessive functions and optimal stopping*, arXiv preprint: `arXiv:2209.11491.`

Representation of solutions to sticky stochastic differential equations

Soledad Torres

CIMFAV - Universidad de Valparaíso

In this talk, we study a representation for the solutions to sticky stochastic differential equations driven by a continuous process. The involved stochastic integral is interpreted in three different ways. Namely, we deal with Young integral defined by the fractional calculus, and the forward and symmetric integrals in the Russo and Vallois sense. The representation obtained in this paper depends on the amount of time spent by the solution at zero.

Funding: This work was supported by Fondecyt Reg. 1221373 and Basal project FB210005.

References:

1. Garzón, Johanna; León, Jorge A. and Torres, Soledad: *Representation of solutions to sticky stochastic differential equations*, Stochastics and Dynamics 2350005 (15 pages) c World Scientific Publishing Company DOI: 10.1142/S0219493723500053 (2023).

Stochastic Differential Equations and Applications II

Organizer: **Christian Olivera**, UNICAMP

Forward stochastic differential equations with discontinuous diffusion

Johanna Garzón

Universidad Nacional de Colombia

In this talk, we study the forward integral, in the Russo and Vallois sense, with respect to Hölder continuous stochastic processes with exponent bigger than $\frac{1}{2}$, such as the fractional Brownian motion. Based on the definition of this integral, we obtain a representation of the solutions to forward stochastic differential equations when the diffusion coefficient is either, the function sgn, or the indicator function of a finite interval in $\mathbb{R}$.

References:

1. Garzón, Johanna; León, Jorge A. and Torres, Soledad: *Forward integration of bounded variation coefficients with respect to Hölder continuous processes*, Bernoulli. To appear.

Weak and strong convergence of the exponential-Euler scheme: a positive preserving time-discretization for SDEs with superlinear growth

Kerlyns Martínez

Institute of Statistics, Valparaiso University

In this talk, we consider the problem of designing a robust time-discretization for the solution of a one-dimensional stochastic differential equation (SDE for short) with non-globally Lipschitz coefficients:

$$dX_t = b(X_t)dt + \sigma X_t^{\alpha} dW_t, \tag{1}$$

where $(W_t; t \geq 0)$ is a standard Brownian motion defined on a given probability space, $\sigma > 0$, $\alpha > 1$ –possibly fractional– and the drift $b : [0, +\infty) \to \mathbb{R}$ satisfies certain superlinear growth condition depending on α.
The literature addressing the numerical approximation of this type of SDEs is numerous, and most of it focuses on a regularity relaxation (regarding globally Lipschitz condition) dedicated only to the drift function, or assumes the control of moments of the time-discrete process, see e.g. [3,4,5,6,8], among others. However, with superlinear growth coefficients, the classical Euler-Maruyama scheme may exhibit some degenerate behavior [7]. In this sense, the time-discretization of the SDE (1) presents two levels of difficulty: it must preserve the strict positivity and guarantee the control of moments of the exact solution.
Based on semi-linear integration methods in numerical analysis, we propose an (semi-explicit) exponential-Euler scheme for which, under some suitable hypotheses on the model parameters, we have shown a rate of weak convergence of order one. This has been done by analyzing the $C^{1,4}$ regularity of the solution of the associated backward Kolmogorov PDE using its Feynman-Kac representation [1]. Furthermore, the analysis of the strong convergence of the Exponential-Euler scheme has been recently performed, obtaining a strong rate of convergence of order 1/2 [2], as is the case of the Euler-Maruyama numerical scheme for SDEs with regular coefficients.

Funding: This work was supported by ANID FONDECYT /POSTDOCTORADO N°321011

Joint work with: **Mireille Bossy**

References:

1. M. Bossy, J-F. Jabir, K. Martínez, *On the weak convergence rate of an exponential Euler scheme for SDEs governed by coefficients with superlinear growth.* Bernoulli, 27:312–347, (2021).

2. M. Bossy, K. Martínez, *Strong convergence and stability of the exponential Euler scheme for SDEs governed by coefficients with superlinear growth.* Work in progress, (2022).

3. J-F. Chassagneux, A. Jacquier, and I. Mihaylov, *An explicit Euler scheme with strong rate of convergence for financial SDEs with non-Lipschitz coefficients.* Society for Industrial and Applied Mathematics, 7:993–1021, (2016).

4. I. Gyongy, *A note on Euler's approximations.* Potential Anal., 8:205–216, (1998).

5. D. Higham, X. Mao, and A. Stuart, *Strong convergence of Euler-type methods for nonlinear stochastic differential equations.* SIAM Numeric Analysis, 40:1041–1063, (2002).

6. M. Hutzenthaler and A. Jentzen, *On a perturbation theory and on strong convergence rates for stochastic ordinary and partial differential equations with non-Globally monotone coefficients.* Ann. Probab., 48(1):53–93, (2020).

7. M. Hutzenthaler, A. Jentzen, and P. Kloeden. *Strong and weak divergence in finite time of Euler's method for SDEs with non-globally Lipschitz continuous coefficients.* Proc. R. Soc., 467:1563–1576, (2010).

8. S. Sabanis, *Euler approximations with varying coefficients: The case of superlinearly growing diffusion coefficients.* Ann. Probab., 26:2083–2105, (2016).

Large Deviations for (1+1)-dimensional Stochastic Geometric Wave Equation

Zdzislaw Brzezniak

University of York

We consider stochastic wave map equation on real line with solutions taking values in a d-dimensional compact Riemannian manifold. We show first that this equation has unique, global, strong in PDE sense, solution in local Sobolev spaces. The main result of the paper is a proof of the Large Deviations Principle for solutions in the case of vanishing noise. This talk is based on a joint research with B Gołdys, M Ondreját and N Rana.

Quantitative particle approximation of nonlinear Fokker-Planck equations with singular kernel

Christian Horacio Olivera

Universidade Estadual de Campinas

In this work, we study the convergence of the empirical measure of interacting particle systems with singular interaction kernels. First, we prove quantitative convergence of the time marginals of the empirical measure of particle positions towards the solution of the limiting nonlinear Fokker-Planck equation. Second, we prove the well-posedness for the McKean-Vlasov SDE involving such singular kernels and the convergence of the empirical measure towards it (propagation of chaos).

Our results only require very weak regularity on the interaction kernel, which permits to treat models for which the mean field particle system is not known to be well-defined. For instance, this includes attractive kernels such as Riesz and Keller-Segel kernels in arbitrary dimension. For some of these important examples, this is the first time that a quantitative approximation of the PDE is obtained by means of a stochastic particle system. In particular, this convergence still holds (locally in time) for PDEs exhibiting a blow-up in finite time. The proofs are based on a semigroup approach combined with a fine analysis of the regularity of infinite-dimensional stochastic convolution integrals. This work is in collaboration with A. Richard and M. Tomasevic.

Optimization and Robustness

Organizer: **Marco Avella Medina**, Columbia University

Mode estimation via Optimal Transport

Mauricio Junca

Universidad de Los Andes, Bogotá

This work concerns the problem of estimating the mode of a random vector. Given a sample of a random vector with unknown distribution, we study the problem of identifying the point in the sample with the highest density. This point can be interpreted as an in-sample estimator of the largest mode of the random vector. We will approach this problem by means of a stochastic optimization problem which we will address via Distributionally Robust Optimization (DRO) using Wasserstein metrics. We will present some consistency results and numerical experiments. This is joint work with Diego Fonseca (UniAndes) y Marco Avella (Columbia University).

Funding: This work was supported by Fondo de Investigaciones de la Facultad de Ciencias de la Universidad de los Andes INV-2021-128-2307 and INV-2022-137-2410.

A new concentration inequality for the optimal transport cost between the true and empirical measure

Johannes Wiesel

Department of Statistics, Columbia University

Let μ be a probability measure on $\mathbb{R}^d$ and μ_N be an empirical measure of μ with sample size N. In this talk we propose a concentration inequality of the optimal transport cost between μ and μ_N, where the cost function has local polynomial growth but can have superpolynomial global growth. This result generalizes and improves upon the estimates by Fournier and Guillin. The main novelty is a combination of rates for compactly supported μ with estimates from empirical process theory. By partitioning $\mathbb{R}^d$ into small cubes, we infer a global estimate from local estimates on these cubes and conclude that the difference between these can be controlled by imposing benign moment conditions on μ.

Acknowlegments: Based on joint work with Martin Larsson and Jonghwa Park.

Funding: This work is supported by NSF Grant DMS-2205534.

On robust statistical estimation

Zoraida F. Rico

Columbia University

The work that we present belongs to a line of research that consists of estimating statistical objects with the best possible non-asymptotic performance. This talk is twofold. First, we show an estimator for the mean of a random variable from an i.i.d. sample. The framework of this problem will prepare the ground for introducing an estimator for least-squares linear regression. We construct this estimator based on a two-stage Multiplicative Weight Update algorithm. We study both problems from the perspectives of adversarial contamination and heavy-tailed data. The results presented in this talk are based on joint works with Roberto I. Oliveira (IMPA), Paulo Orenstein (IMPA), and Philip Thompson (Purdue University).

On the Robustness to Misspecification of α-Posteriors and Their Variational Approximations

Cynthia Rush

Columbia University

Variational inference (VI) is a machine learning technique that approximates difficult-to-compute probability densities by using optimization. While VI has been used in numerous applications, it is particularly useful in Bayesian statistics where one wishes to perform statistical inference about unknown parameters through calculations on a posterior density. In this talk, I will review the core concepts of VI and introduce some new ideas about VI and robustness to model misspecification. In particular, we will study α-posteriors, which distort standard posterior inference by downweighting the likelihood, and their variational approximations. We will see that such distortions, if tuned appropriately, can outperform standard posterior inference when there is potential parametric model misspecification. This is joint work with Marco Avella, José Montiel Olea, and Amilcar Velez.

Differentially private inference via noisy optimization

Marco Avella Medina

Columbia University

We propose a general optimization-based framework for computing differentially private M-estimators and a new method for the construction of differentially private confidence regions. Firstly, we show that robust statistics can be used in conjunction with noisy gradient descent and noisy Newton methods in order to obtain optimal private estimators with global linear or quadratic convergence, respectively. We establish global convergence guarantees, under both local strong convexity and self-concordance, showing that our private estimators converge with high probability to a neighborhood of the non-private M-estimators. The radius of this neighborhood is nearly optimal in the sense it corresponds to the statistical minimax cost of differential privacy up to a logarithmic term. Secondly, we tackle the problem of parametric inference by constructing differentially private estimators of the asymptotic variance of our private M-estimators. This naturally leads to the use of approximate pivotal statistics for the construction of confidence regions and hypothesis testing. We demonstrate the effectiveness of a bias correction that leads to enhanced small-sample empirical performance in simulations.

This is joint work with Casey Bradshaw and Po-Ling Loh.

Bayesian Methods for Complex Data Analysis

Organizer: **Fernando Quintana**, Pontificia Universidad Católica de Chile

Variational Inference for Bayesian Bridge Regression

Carlos Tadeu Pagani Zanini

Universidade Federal do Rio de Janeiro

The bridge regularization in regression models uses ℓ_α norm to define a penalization on large values of the regression coefficients. Particular cases include the lasso and ridge penalizations. Although MCMC approaches are available for Bayesian bridge regression, they can be very slow for large datasets, specially in high dimension. We develop an implementation of Automatic Differentiation Variational Inference for Bayesian inference on semi-parametric regression models with bridge penalization. Non-parametric covariate effects are modelled by B-splines. The proposed inference procedure drastically reduces computational time in comparison with MCMC while preserving full Bayesian inference. Joint work with Helio dos Santos Migon and Ronaldo Dias.

Funding: This work was partially supported by Fapesp Grants 2018/04654-9 (R. Dias)
2018/04654-9, (R. Dias and H. S.Migon) 2019/10800-0 and (R. Dias) 2019/00787-7.

References:

1. Zanini, C. T. P., Migon, H. S., Dias, R.: *Variational Inference for Bayesian Bridge Regression*, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-1979570/v1], (2022).

Stick-breaking processes with dependent length variables

Maria Fernanda Gil Leyva Villa

DPyE–IIMAS–UNAM

The stick-breaking decomposition of weights sequences, in terms of [0, 1]-valued length variables, has served as a method to define Bayesian nonparametric priors. The most popular choice being the case where length variables are independent. Although there are a handful of examples of stick-breaking weights with explicitly dependent length variables, the general case has remained somehow elusive due to the mathematical hurdles to overcome. Here we study the general classes of stick-breaking processes with exchangeable or Markovian length variables. We give conditions to assure they lead to feasible Bayesian non parametric priors. For a rich subclass we explain how, by tuning a single [0,1]-valued parameter, the stochastic ordering of the weights can be modulated, and well-known species sampling processes (such as Dirichlet, Pitman-Yor and Geometric processes) can be recovered. By means of a simulation study we illustrate the good performance of the novel class for density estimation and clustering purposes.

Childhood Obesity in Singapore: a Bayesian Nonparametric Approach

Fernando Andrés Quintana

Pontificia Universidad Católica de Chile

Overweight and obesity in adults are known to be associated with increased risk of metabolic and cardiovascular diseases. Obesity has now reached epidemic proportions, increasingly affecting children. Therefore, it is important to understand if this condition persists from early life to childhood and if different patterns can be detected to inform intervention policies. Our motivating application is a study of temporal patterns of obesity in children from South Eastern Asia. Our main focus is on clustering obesity patterns after adjusting for the effect of baseline information. Specifically, we consider a joint model for height and weight over time. Measurements are taken every six months from birth. To allow for data-driven clustering of trajectories, we assume a vector autoregressive sampling model with a dependent logit stick-breaking prior. Simulation studies show good performance of the proposed model to capture overall growth patterns, as compared to other alternatives. We also fit the model to the motivating dataset, and discuss the results.

Funding: This work was supported by FONDECYT grants 1180034 and 1220017

Probabilistic Models for Latent Variables

Organizer: **Jorge González**, Pontificia Universidad Católica de Chile

---

A multi-unidimensional item response theory model using latent distance correlation structure

Pedro Araújo

University College Dublin

Item response theory models are a popular tool to estimate latent traits in several research fields, especially in psychology and education. In cases where the same individual responds to a set of different tests, where each test measures a unique latent trait using distinct items, we can employ multi-unidimensional item response theory models. For this class of model, it is reasonable to consider some association between the individual latent traits. It can be done assuming that the *prior* distribution for the individual vector with all latent traits follows a multivariate normal distribution with an associated correlation matrix common to all respondents. The correlation matrix can be modeled with a Wishard *prior*, rescaling it to be a correlation matrix; an LKJ distribution, which is a probability distribution for correlation matrices; or induce the association with a hierarchical model. In our proposal, we modeled the correlation between the latent traits assuming that each test, which represents the concept behind the latent trait being measured, is spatially distributed in a Euclidean latent space. We assume that closer concepts will present a higher correlation, then the correlation between two latent traits will depend on the latent distance between the two tests and a scale parameter. In summary, for the vector with individual latent traits, we assume a Gaussian process with an exponential kernel with latent distances. With this structure, we can visualize the relationship between the latent traits in a two-dimensional graph, summarise the overall correlation with the scale parameter, and cluster the tests since we have estimates for the latent distances. We used Bayesian inference to estimate the parameters, and due to the fact that the *posterior* distribution does not have a closed form, we generated samples from the *posterior* using Hamiltonian Monte (HMC) Carlo with the NUTS variation of the algorithm. The final implementation was with the Stan programming language available in R through the package *rstan*. To assess the estimation procedure we performed a simulation study, we first generated data with the proposed correlation structure and then estimated the model parameters for different numbers of tests and different scale parameters. The HMC handles well the parameter estimation, with a good estimation of the latent distances when there is an association between the latent traits. We also applied the model to data from the Brazilian national high school exam (Exame Nacional do Ensino Medio). In this exam, the same student takes four tests: languages, social science, natural science, and mathematics. We applied our proposed correlation structure, the LKJ *prior*, and also estimated the latent traits assuming independence between the tests. The final estimated correlation matrix for the proposed model and with LKJ *prior* is similar, the independent *prior* presented lower correlations, possibly underestimating the association between the latent traits. And although the LKJ *prior* and the proposed *prior* presented similar results, with the proposed model we can visualize and cluster the tests, and with that, we have more insights about the association between the latent traits.

Acknowlegments: I thank my master's supervisor Marcia Branco for the support and good advice during the project when I was a student at the Institute of Mathematics and Statistics of the University of São Paulo.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001".

Some Counts Item Response Models

Jorge Luis Bazán

University of Sao Paulo

Count Item Response Theory (IRT) Models identify individual latent traits and facilities of the items of tests that model the error (or success) count in several tasks over time. These types of models can be more informative than traditional dichotomous IRT models. In this talk we introduce the main models in this area and propose some new models. Data used to illustrate the estimation of the models studies comes from 228 people who took a selective attention test. Finally, we discuss extensions and challenges for future developments in the area.

Acknowlegments: Jorge L. Bazán acknowledges support from FAPESP-Brazil (Grant 2021/11720-0)

Some Counts Item Response Models

Jorge Luis Bazán

University of Sao Paulo

Count Item Response Theory (IRT) Models identify individual latent traits and facilities of the items of tests that model the error (or success) count in several tasks over time. These types of models can be more informative than traditional dichotomous IRT models. In this talk we introduce the main models in this area and propose some new models. Data used to illustrate the estimation of the models

studies comes from 228 people who took a selective attention test. Finally, we discuss extensions and challenges for future developments in the area.

Acknowlegments: Jorge L. Bazán acknowledges support from FAPESP-Brazil (Grant 2021/11720-0)

Using VAE for Incomplete Educational Data

Claudia Evelyn Escobar Montecino- Mariana Cúri

Programa Interinstitucional de Pos-Graduação em Estatística

In Psychometrics, and in particular in educational assessments, it is common to find incomplete databases. Lack of time, forgetting the content involved, nervousness or even the test design are some of the reasons why an individual may leave items unanswered in an assessment. In this context, it is important to have estimation methods for psychometric models that deal with missing data and are affected as little as possible by the lack of information in those unanswered items. In a small-scale scenario, traditional estimation methods for Item Response Theory (IRT) models, for example, are suitable for situations with complete and incomplete data. However, for high-dimensional situations, such as assessments involving many latent skills and abilities, traditional methods are not computationally efficient or even unable to obtain estimates for so many parameters. Deep learning has been adapted to incorporate IRT models and make predictions and estimates from large, high-dimensional databases. In this work, we deepen the investigation of Curi, who defined a Two Parameter Logistic Model (ML2P) in the architecture of a variational autoencoder (VAE) as a proposal to solve the problem of estimating the many parameters of the model. We performed a simulation study to compare two variations of deep neural networks, autoencoders (AE) and VAE, defined with an ML2P model in the decoder, for situations with a large number of latent traces and complete data. After favorable results of the VAE, we propose an extension of the same (IVAE) to be able to make predictions in cases of missing data and, thus, make the model more general and useful in practice. Simulations of the proposed model were performed under different scenarios to investigate the efficiency of the new method in recovering the parameters. Comparisons of the results with one of the methodologies currently most indicated in IRT to deal with a situation of greater dimensionality, the joint maximum likelihood, were also made, in addition to the application to a real case of high dimension and with missing data.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001

References:

1. Reckase, M.: *Multidimensional Item Response Theory.*, Springer (2009).

2. Converse, G. and Curi, M. and Oliveira, S.: *Autoencoders for Educational Assessment*, 20th Annual Conference on Artificial Intelligence in Education (AIED) (2019).

3. Cúri, M. and Converse, G. and Hajewski, J. and Oliveira, S.: *Interpretable Variational Autoencoders for Cognitive Models*, International Joint Conference on Neural Networks (IJCNN) (2019)

On the unidentifiability of the fixed-effects 1PL-LPE model

Jorge González

Pontificia Universidad Católica de Chile, Chile
Millennium Nucleus on Intergenerational Mobility: From Modelling to Policy (MOVI), Chile

Two commonly used item response functions (IRF) item response theory models are the logistic and the standard normal cumulative distribution function (a.k.a normal-ogive model). A particular feature of the logistic and normal IRFs is that both lead to symmetric item characteristic curves (ICC) with the axis of symmetry being the point at which the probability of answering correctly is 0.5. It has been recognized, however, that it is sometimes better using an asymmetric IRF to model binary scored data. A model introduced by Samejima (1995) that allows for asymmetry of the ICCs is called the logistic positive exponent model (LPE). In this model, the asymmetry is accounted for by incorporating an exponent parameter. In despite of the increasing research around the LPE model, and the fact that is has being used in some applications, there are important aspects regarding the LPE model that have not yet been considered in the literature and that are likely to have an impact on both theory and practice. Parameter identifiability is one of those relevant aspects. The aim of this paper is to develop an identifiability analysis of the 1PL-LPE model. Lack of identifiability result in a meaningless statistical model. It is shown that the model is not always identifiable. Thus, although the LPE model has been rediscovered and used in practice in assessment, this paper shows that technical requirements, such as model identifiability, are needed to ensure correct and useful inferences that lead to good policy practices.

Funding: The author acknowledges the partial financial support of the FONDECYT Project No. 1230968 and the Agencia Nacional de Investigacion y Desarrollo (ANID) Millennium Nucleus on Intergenerational Mobility: From Modelling to Policy (MOVI); (NCS2021072).

Contributed Talks

CT1 - Random walks and Brownian motion

A Central Limit Theorem for intransitive dice

Daniel Ungaretti

UFRJ

Consider dice that are allowed to have different number of faces and any number on each face. Die A is said to be better than die B, denoted $A \triangleright B$, if it has a larger probability of winning. This ordering of dice is not transitive: it is possible that $A \triangleright B \triangleright C \triangleright A$. In this talk we present results on the probability of random dice (with iid. faces) forming an intransitive chain, as the number of faces of each die goes to infinity. We prove a Central Limit Theorem for such dice, combining the method of moments with simple graph theory arguments.

Acknowlegments: This work is the result of "Jornadas de pesquisa para graduação", a summer program for introducing graduate students to research topics. It was developed during the summer program of ICMC-USP, São Carlos, in 2023.

Funding: This work was partially supported by São Paulo Research Foundation (FAPESP) under Grant # 2019/16062-1, and also by the Centro de Ciências Matemáticas Aplicadas à Industria (CeMEAI - CEPID) under FAPESP Grant # 2013/07375-0

References

[1] Bueno, L. G. C.; Franco, T.; Lima, L. V.; de Paula, J. P. C.; Pi-

menta, J. V. A.; Silva, G. L. F. and Ungaretti, D.: *A Central Limit Theorem for intransitive dice*, in preparation.

Polynomial ballisticity conditions and invariance principle for random walks in strong mixing environments

Glauco Valle

Universidade Federal do Rio de Janeiro

We study ballistic conditions for d-dimensional random walks in strong mixing environments (RWRE), with underlying dimension $d \geq 2$. Specifically, we introduce an effective polynomial condition similar to that given by Berger, Drewitz and Ramírez in [1]. In a mixing setup we prove this condition to imply the corresponding stretched exponential decay, and obtain an annealed functional central limit theorem for the random walk process centered at velocity. This complements a previous work of Guerra [3] and completes the answer about the meaning of condition $(T')|\gamma$ in a mixing setting, an open question posed by Comets and Zeitouni in [2].
Joint work with Maria Eulalia Vares (UFRJ) and Enrique Guerra, see [4].

Funding: This work was supported by CNPq grant 308006/2018-6 and FAPERJ grant E-26/203.048/2016.

References

[1] Berger, Noam and Drewitz, Alexander and Ramírez, Alejandro: *Effective Polynomial Ballisticity Conditions for Random Walk in Random Environment*, Comm. Pure Appl. Math. 77, 1947–1973 (2014).

[2] Comets, Francis and Zeitouni, Ofer: *A law of large numbers for random walks in random mixing environments*, Ann. Probab. 32, 880–914 (2004).

[3] Guerra, Enrique: *On the transient (T) condition for random walk in strong mixing environment*, Ann. Probab. 47, 3003–3054 (2019).

[4] Guerra, Enrique and Valle, Glauco and Vares, Maria Eulalia: *Polynomial ballisticity conditions and invariance principle for random walks in strong mixing environments*, Probab. Theory and Related Fields 182, 685-750 (2022).

On the minimal random walk and its relation with Pólya urns

Víctor Hugo Vázquez Guevara

Facultad de Ciencias Físico Matemáticas, Benemérita Universidad Autónoma de Puebla

In this talk we present some asymptotic results on the Minimal Random Walk which is the simplest one that posses infinite memory and three dispersion regimes. In addition, we show its relation with a Pólya urns scheme which will lead us to a functional central limit theorem.

Funding: This work was supported by Vicerrectoría de Investigación y Estudios de Posgrado de la Benemérita Universidad Autónoma de Puebla

References

[1] Bercu, Bernard and Vázquez Guevara, Víctor Hugo: *Further results on the minimal random walk,* Journal of Physics A: Mathematical and Theoretical, Volume 55, Number 41 (2022).

[2] Coletti, Cristian, Renato, Gava and and de Lima, Lucas: *Limit theorems for a minimal random walk model,* J. Stat. Mech. 083206 (2019).

Growth-fragmentation embedded in Brownian excursions from hyperplanes

Juan Carlos Pardo

Centro de Investigación en Matemáticas, A.C.

In this talk, we present a self-similar growth-fragmentation process linked to a Brownian excursion from hyperplanes, obtained by cutting the excursion at heights along horizontal hyperplanes. More precisely by slicing these excursions, we obtain a collection of excursions which exhibit a branching structure. We define the size of such an excursion as the difference between the endpoint and the starting point. We show that considering the collection of these sizes at varying heights construct a special growth-fragmentation in $\mathbb{R}^{d-1}$. This is a joint work with William Da Silva (University of Vienna)

Directed Polymer for very heavy tailed random walks

Roberto Viveros

IME - USP

In the literature on directed polymers in random environments, two notions of strong disorder emerged: the first one is based on whether or not the partition function converges to zero and is known as strong disorder. The second depends on whether the Lyapunov exponent associated with the partition function is negative or not and is known as very strong disorder. Each of these notions corresponds to a critical temperature. Very strong disorder implies strong disorder and a conjecture for directed polymers is that these two critical points coincide. However, we will present special cases for which there is not a very strong disorder phase, while strong disorder is maintained at sufficiently low temperature. This shows that the conjecture cannot be held to complete generality.

References

[1] Viveros, Roberto: *Directed polymer for very heavy tailed random walks*, Ann. Appl. Probab. 33(1): 490-506 (February 2023). DOI: 10.1214/22-AAP1821

Soliton decomposition of a Brownian path

Ines Armendariz

Universidad de Buenos Aires, IMAS UBA-CONICET

The Box Ball System, or BBS for short, was introduced by Takahashi and Satsuma in 1990 as a cellular automaton that exhibits solitons (travelling waves). In a recent work, Ferrari, Nguyen, Rolla and Wang [1] propose a hierarchical decomposition of a fixed configuration of the BBS in solitons, called the slot decomposition, and Ferrari and Gabrielli [2] identified the distribution of this decomposition for a random walk with negative drift. In this project we extend these results to a Brownian motion with negative drift. We consider the excursions over past minima of the trajectory, and show that they can be decomposed as a superposition of solitons. These are distributed as a Poisson process in the first quadrant of the plane, with an intensity that is homogeneous in the abscissa (associated to the location of the solitons) but not in the ordinate (denoting the size of the solitons).

Ongoing work with Pablo Blanc, Pablo Ferrari and Davide Gabrielli

References

[1] Ferrari, Pablo A.; Nguyen, Chi; Rolla, Leonardo T.; Wang, Minmin: *Soliton decomposition of the box-ball system*, Forum Math. Sigma 9, 37 pp. (2021).

[2] Ferrari, Pablo A.; Gabrielli, Davide: *BBS invariant measures with independent soliton components*, Electron. J. Probab. 25, 26 pp. (2020).

CT2 - Models on random trees and graphs

The asymptotic shape of first-passage percolation models on random geometric graphs and its speed of convergence

Lucas R. de Lima

Universidade Federal do ABC, Brazil

In recent years, the study of random geometric graphs and their properties has attracted a great deal of attention in the field of probability theory. In this talk, we focus on the first-passage percolation model with independent and identically distributed random variables on the infinite connected component of a random geometric graph. We provide sufficient conditions for the existence of the asymptotic shape and we show that the shape is an Euclidean ball. We illustrate our findings by giving examples from the Bernoulli percolation and the Richardson model. In addition, we show that for the Richardson model, the model converges weakly to a nonstandard branching process in the joint limit of large intensities and slow passage times.

We will also discuss ongoing research on the speed of convergence and applications of these random processes. This talk is based on [1] and derived projects.

Acknowlegments: The research was partially completed when L.R. de Lima visited the Department of Mathematics of the Bernoulli Institute at the University of Groningen. He is thankful for their hospitality. We thank the team from Orange S.A. as well as W. König and A. Tóbiás for inspiring discussions.

Funding: This work was supported by grants #2017/10555-0, #2019/19056-2, and #2020/12868-9, São Paulo Research Foundation (FAPESP). Research also funded by the German Research Foundation under Germany's Excellence Strategy MATH+: The Berlin Mathematics Research Center, EXC-2046/1 project ID: 390685689, Orange Labs S.A., and the German Leibniz Association via the Leibniz Competition 2020.

References

[1] Coletti, Cristian F.; de Lima, Lucas R.; Hinsen, Alexander; Jahnel, Benedikt and Valesin, Daniel: *Limiting shape for First-Passage Percolation models on Random Geometric Graphs*, Journal of Applied Probability, 60, 4 (in press). Preprint available at arXiv:2109.07813.

Critical surface for the multi-edges percolation model on oriented homogeneous trees

Sandro Gallo

Universidade Federal de São Carlos

de Lima, Rolla and Valesin (2019) introduced and studied the 2-edges percolation model on homogeneous oriented trees $\mathbb{T}_d$. In this model, small (length one) edges are opened with probability p and long (length $k > 1$) edges are opened with probability q. Here, in the slightly more general setting of m-edges ($m \geq 2$), we obtain the critical surface as the set of 0's of a specific polynomial with coefficients depending on d. Specializing to the original 2-edges case, we can extract bounds for the critical parameters, which are valid for any d and k.

Funding: This work was supported by FAPESP "Auxílio Regular" (2019/23439-4)

Spatial Gibbs Random Graphs

Andressa Cerqueira

Universidade Federal de São Carlos

In this talk, I will present a Spatial Gibbs Random Graph Model on Z^d that incorporates the interplay between the statistics of the graph and the underlying space where the vertices are located. For this model, we prove the existence and uniqueness of a measure defined on graphs with vertices in Z^d as the limit along the measures over graphs with finite vertex set. I will explain how the results are obtained based on a graphical construction of the model as the invariant measure of a birth and death process. This is a joint work with Nancy Garcia.

Funding: This work was supported by grant #2017/25926-4, São Paulo Research Foundation (FAPESP).

1. Cerqueira, Andressa and Nancy L. Garcia: *Graphical construction of spatial Gibbs random graphs.*, Journal of Mathematical Physics 63, 043304 (2022).

Long-range contact process on a dynamic random graph

Pablo A. Gomes

IME-USP

The subject of this talk is a long-range contact process on a random graph. The set of vertices is $\mathbb{Z}$ and the set of edges is random and dynamic. The range of each vertex are independent, updated dynamically and, at each update, given by some distribution N. The conclusion consists in the presentation of results concerning the existence of phase transition of the model in terms of the distribution N. This talk is based on a joint work with Bernardo Lima ([1]).

Funding: This work was supported by São Paulo Research Foundation (FAPESP), grant 2020/02636-3.

References

[1] Gomes, Pablo A. and de Lima, Bernardo N.B.: *Long-range contact process and percolation on a random lattice*, Stochastic Processes and their Applications, 153, 21–38, (2022).

CT3 - Applied Probability Models

Relative vs absolute fitness in a population genetics model. How stronger selection may promote genetic diversity.

Alejandro Hernández Wences

LAAS-CNRS

In this talk I will describe a recent work together with Emmanuel Shcertzer where we study an exactly solvable population model that shows that the belief that "directional selection should reduce genetic diversity" is not always correct. The population is modelled as a cloud of particles evolving in a 1-dimensional fitness space (fitness wave). We show the existence of a phase transition which separates the parameter space into a weak and a strong selection regimes. We find that genetic diversity is highly non-monotone in the selection strength and, in contrast with the common intuition, our model predicts that genetic diversity is typically higher in the strong selection regime. This apparent paradox is resolved by observing that a higher selection strength increases the absolute fitness of the wave, but typically generate lower relative fitness between individuals within the wave. These findings entail that inferring the magnitude of natural selection from genetic data may raise some serious conceptual issues.

Along the way, we uncover a new phase transition in front propagation. Namely, we show that the transition from weak to strong selection can be reformulated in terms of a transition from fully-pulled to semi-pulled waves. This transition is the pulled analog to the semi-pushed to fully-pushed regimes observed in noisy-FKPP travelling waves in the presence of Allee effect.

Dependent Stopping Times and an Application to Credit Risk Theory

Alejandra Quintos.

University of Wisconsin-Madison.

Stopping times are used in applications to model random arrivals. A standard assumption in many models is that the stopping times are conditionally independent, given an underlying filtration. This is a widely useful assumption, but there are circumstances where it seems to be unnecessarily strong. In the first part of the talk, we use a modified Cox construction, along with the bivariate exponential introduced by Marshall & Olkin (1967), to create a family of stopping times, which are not necessarily conditionally independent, allowing for a positive probability for them to be equal. We also present a series of results exploring the special properties of this construction. In the second part of the talk, we present an application of our model to Credit Risk. We characterize the probability of a market failure which is defined as the default of two or more globally systemically important banks (G-SIBs) in a small interval of time. The default probabilities of the G-SIBs are correlated through the possible existence of a market-wide stress event. We show the impact of increasing the number of G-SIBs and that if there are too many G-SIBs, a market failure is inevitable, i.e., the probability of a market failure tends to one as the number of G-SIBs tends to infinity. We end the talk with some related and outgoing work that uses phase-type distributions.

Acknowlegments: I thank my collaborators: Robert Jarrow, Yisub Kye, Philip Protter, and Jianxi Su.

Funding: This work was supported by the Office of the Vice Chancellor for Research and Graduate Education at the University of Wisconsin–Madison with funding from the Wisconsin Alumni Research Foundation and by the Fulbright-García Robles Program. One of my collaborators (Philip Protter) was supported by NSF Grant DMS-2106433

References:

1. Protter, Philip and Quintos, Alejandra: *Stopping Times Occurring Simultaneously*, Available online: https://arxiv.org/abs/2111.09458 (2022).
2. Jarrow, Robert, Protter, Philip and Quintos, Alejandra: *Computing the Probability of a Financial Market Failure: A New Measure of Systemic Risk*, Annals of Operations Research (2022).
3. Kye, Yisub, Quintos, Alejandra and Su, Jianxi: *Multiple Risk Factor Dependence Induced by Phase-Type Distributions*, Preprint (2023+).

A proposal of stochastic prey-switching for Lotka-Volterra models

Leonardo Videla (joint work with María Isidora Ávila-Thieme and Mauricio Tejo)

DMCC, Universidad de Santiago de Chile

In this talk I present some preliminary results regarding an ecological model based on a stochastic Lévy-driven Lotka-Volterra type SDE where some of the predators exhibit prey-switching behavior. We propose a Markov process (X_t, A_t) taking values in the product of the positive orthant and a cone of matrices, where the first component represents the abundance process and the second component (the community process) represents the evolution of the interaction strengths between species due to the prey-switching mechanism. The main focus is on the coexistence of the whole community; in particular, we intend to study how the prey-swtiching mechanism promotes persistence. We prove some basic facts about the coupled process and study in some detail the matrix component when taken in isolation from the abundance process.

Funding: This work is supported by Project ANID EXPLORACION 13220168 *Biological and quantum open system dynamics: evolution, innovation and mathematical foundations*

References

[1] Videla, Leonardo: *Strong stochastic persistence of some Lévy-driven Lotka-Volterra systems*, J. Math. Biol. 84, 11 (2022). https://doi.org/10.1007/s00285-022-01714-6 (2022) .

[2] Videla, Leonardo: *A transport process on graphs and its limiting distributions*, Journal of Applied Probability, 1-17. doi:10.1017/jpr.2022.47 (2022) .

Extinction time in growth models subject to geometric catastrophes

Frabio Prates Machado

Universidade de São Paulo

Recently, different dispersion strategies in population models subject to geometric catastrophes have been considered as strategies to improve the chance of population's survival. Such dispersion strategies have been contrasted with the strategy where there is no dispersion, comparing the probabilities of survival. In this article, we contrast survival strategies when extinction occurs almost surely, evaluating which strategy prolongs population's life span. Our results allow one to analyze what is the best strategy based on parameters as the probability that each individual exposed to catastrophe survives, the growth rate of the colony, the type of dispersion and the spatial restrictions.

Community detection in the Stochastic Block Model

Florencia Leonardi

University of São Paulo

In this talk I will present the fundamental results in the literature on community estimation in the Stochastic Block Model (SBM) with k communities, not necessarily symmetric (all communities of the same size), focusing mainly on the maximum likelihood method. This approach was previously considered by Chen and Bickel (2009), but the proof of the consistency of the maximum likelihood estimator presents some points that are still open and not fully justified, as pointed out in van der Pas and van der Vaart (2018). In this work, we show, using different concentration inequalities, that the maximum likelihood estimator is consistent above the phase transition threshold, for networks with logarithmic degree regime, completing the proof of Chen and Bickel (2009) and generalizing these results. This is a joint work with Andressa Cerqueira (UFSCAR).

Acknowlegments: I thank...

Funding: This work was supported by FAPESP

References

[1] Surname, Name and Surname, Name: *title of article*, Journal's name, number, issue, pages range (year).

CT4 - Statistical Models and Applications

Power logit regression for modeling bounded data

Francisco F. Queiroz

University of São Paulo

In this work we introduce a new class of regression models for bounded continuous data, such as continuous proportions, scores and rates. The models, named the power logit regression models, assume that the response variable follows a distribution in a wide, flexible class of distributions with three parameters, namely the median, a dispersion parameter and a skewness parameter. We offer a comprehensive set of tools for likelihood inference and diagnostic analysis, and introduce the new `R` package `PLreg`. Applications with real and simulated data show the merits of the proposed models, the statistical tools, and the computational package. This is a joint work with Silvia L. P. Ferrari.

Funding: This work was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001 and by the Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brazil (CNPq). The second author gratefully acknowledges funding provided by CNPq (Grant No. 305963-2018-0).

References

[1] Queiroz, Francisco F. and Ferrari, Silvia L. P.: *Power logit regression for modeling bounded data*, Statistical Modelling, to appear (2023).

SURE-tuned Bridge Regression

Jorge Loría

Purdue University, Department of Statistics

Consider the ℓ_α regularized linear regression, also termed Bridge regression. For $\alpha \in (0,1)$, Bridge regression enjoys several statistical properties of interest such as sparsity and near-unbiasedness of the estimates [**?**]. However, the main difficulty lies in the non-convex nature of the penalty for these values of α, which makes an optimization procedure challenging and usually it is only possible to find a local optimum. To address this issue, [**?**] took a sampling based fully Bayesian approach to this problem, using the correspondence between the Bridge penalty and a power exponential prior on the regression coefficients. However, their sampling procedure relies on Markov chain Monte Carlo (MCMC) techniques, which are inherently sequential and not scalable to large problem dimensions. Cross validation approaches are similarly computation-intensive. To this end, our contribution is a novel *non-iterative* method to fit a Bridge regression model. The main contribution lies in an explicit formula for Stein's unbiased risk estimate for the out of sample prediction risk of Bridge regression, which can then be optimized to select the desired tuning parameters, allowing us to completely bypass MCMC as well as computation-intensive cross validation approaches. Our procedure yields results in about 1/8th to 1/10th of the computational time compared to iterative schemes, without any appreciable loss in statistical performance. An `R` implementation is publicly available online at: `https://github.com/loriaJ/Sure-tuned_BridgeRegression`https://github.com/loriaJ/Sure-tuned_BridgeRegression.
This is joint work with Anindya Bhadra. The full manuscript is available in `https://arxiv.org/abs/2212.02709`https://arxiv.org/abs/2212.02709

Unsupervise Bayesian classification for mixed regression models with applications to predicting illness for milking cows

Nancy Lopes Garcia

Universidade Estadual de Campinas (UNICAMP)

We perform unsupervised classification of a scalar response into one of L components of a mixture modeling a scalar response according to Zero Inflated Mixture of Poisson distributions (ZIMP) and the second level modeling the mixture probabilities by means of a generalised linear model with functional and scalar covariates. We use B-spline expansion to reduce the dimensionality and a Bayesian approach for estimating the parameters and providing predictions of the latent classification vector. The Bayesian approach considers the classical Markov Chain Monte Carlo method as well as the Variational Bayes method. We apply our methodology to data on daily clinical examination of cows during the first 40 Days after calving (days in milk) from 258 cows. Information on whether a cow had a health disorder (1) or not (0) was collected by the research team on a daily basis. The data consists of 41 rows (0-40) per cow with sensor and non-sensor data from the previous lactation (i.e., before calving) and after calving. We focused on four sensor parameters related to physical activity for the 30 days prior to calving. The objective of this application example was to model the number of days a cow was sick in the first 40 days after calving. Our main goal was to classify cows into 2 or 3 classes of status by using the scalar and functional covariates related to activity and resting times.

Acknowlegments: Joint work with Mariana Rodrigues-Motta, Helio S. Migon, Julio O. Giodano and Martin Matias Perez. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the National Institute of Food and Agriculture (NIFA) or the United States Department of Agriculture(USDA).

Funding: This work was partially financed by NIMH grant 5 R01 MH099003, USDA National Institute of Food and Agriculture Animal Health program award 2017-67015-26772 to Julio Giordano, FAPESP grants 2017/15306-9, 2018/06811-4 and 2019/ 10800-0, CNPq grants 302598/2014-6, 442012/2014-4 and 304148/2020-2.

A Unified Framework for Sequential Parameter Learning with Regularization in State Space Models

Uriel Moreira Silva

Universidade Federal de Minas Gerais - Departamento de Estatística, Instituto de Ciências Exatas

A unified framework for sequential parameter learning in state space models is proposed. This framework is capable of accommodating several other algorithms found in the literature as special cases, and this generality is achieved mainly by providing an alternative formalism to the role of regularization in this setting. In order to illustrate its flexibility, three algorithms are developed within this framework, including an improved and fully-adapted version of the celebrated Liu and West filter. These regularization techniques are associated with efficient resampling schemes, and their use is illustrated in challenging nonlinear settings with both synthetic and real-world data.

Funding: Uriel Silva's research was partially funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), and Luiz Duczmal's research was partially funded by Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), grant PPM-00596-17.

Posters

Recurrent neural network for protein family classification and comparing with variable length markov chains

Alexandre Felix

Instituto de Matematica e Estatistica
Universidade de Sao Paulo

In this poster I will present a possible neural network for classification of proteins using recurrent neural networks methods [1], that diferent from usual neural networks, assumes dependence, it is used in text analysis and genetic sequence analysis. And I pretend to compare modern neural networks methods with classical variable length markov chain method [2].

Acknowlegments: I thanks to my supervisor Florencia and FAPESP for support

Funding: This work was supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)

References

1. Maxwell L. Bileschi, David Belanger, Drew H. Bryant, Theo Sanderson, Brandon Carter, D. Sculley, Alex Bateman, Mark A. DePristo, and Lucy J. Colwell.: *Using deep learning to annotate the protein universe*, Nature Biotechnology, 40(6):932–937, 2022.

2. Florencia G. Leonardi.: *A generalization of the PST algorithm: modeling the sparse nature of protein sequences.*, Bioinformatics, 22(11):1302–1307, 03 2006.

3. G. James, D. Witten, T. Hastie, and R. Tibshirani.: *The elements of statistical learning: data mining, inference and prediction.*, Springer, 2 edition, 2009.

4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville.: *Deep Learning.*, MIT Press, 2016

Covariant Rough Integration

Alvaro Enrique Machado Hernandez

Universidade Estadual de Campinas

In this post we shall talk about covariant rough integration on manifolds basing ourselves on covariant stochastic integration in vector bundles, studied by Noris in [?], and in the theory of rough paths on manifolds, studied by Armstrong, Brigo and Cass in [?].

Acknowlegments: I thank God for the fact that He has been my guide, my family and wife for supporting me unconditionally and CAPES for supporting my research.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) Finance Code 001

Large deviation view on processes with catastrophes

Yambartsev, A.

Intitute of Mathematics and Statistics, IME-USP

We extend and generalize our results on the principle of large deviations for a class of Poisson processes with catastrophes. We provide here a general definition of catastrophes. We prove that the rate function will be the same for different distributions of catastrophic events.

Joint work with Logachov, A. (Novosibirsk State University, Russia).

Funding: Supported by FAPESP via grants 2022/01289-3 and 2017/10555-0

Modeling, Analysis, and Estimation of Epidemic Dynamics with stochastic perturbations: Applied to acute respiratory diseases in Bogotá (Colombia).

Andrés Ríos-Gutiérrez[1], Viswanathan Arunachalam[2]

[1]Universidad Industrial de Santander (Bucaramanga, Colombia), [2]Universidad Nacional de Colombia (Bogotá, Colombia)

In this talk, we propose a stochastic epidemic model with random perturbations [1, 2] to study acute respiratory diseases in Bogotá. The random perturbations in the model allow us to include the impact of variations due to external factors, notably, the effect of the particulate matter PM10 and PM2.5 on the air quality due to recent climate change and one of the leading global health issues. We consider a spatial interpolation methodology to analyze the particulate matter information collected in Bogotá and as a covariate of the proposed model. Finally, the model's parameters are estimated using the updated data estimation, and we use the Akaike information criterion (AIC) to validate the model.

Acknowlegments: We thank Secretaría Distrital de Bogotá for providing the statistical data of acute respiratory disease in Bogotá for this study

References

1. Ríos-Gutiérrez, Andrés; Arunachalam, Viswanathan; and Torres, Soledad: *Studies on the basic reproduction number in stochastic epidemic models with random perturbations*, Advances in Difference Equations 2021, 288 (2021).

2. Can, Chen; and Yanmei, Kang: *Dynamics of a Stochastic SIS Epidemic Model with Saturated Incidence*, Abstract and Applied Analysis, vol. 2014, Article ID 723825, 13 pages, 2014.

Consistent estimation of the number of clusters in a multivariate mixture Gaussian model

Anny K G Rodrigues
Florencia G Leonardi

Institute of Mathematics and Statistics University of São Paulo (IME-USP)

K-means is one of the most popular clustering methods because it is easy to interpret and has good convergence properties [1]. A limitation of this algorithm is that the number of groups k needs to be specified by the user. Estimate the number of groups is usually an ad-hoc decision as the distribution of the data is unknown. [2]. In most works use validation indexes, in which the optimal number of groups is "estimated" from the graphical evaluation between the index and different values of k. The correct number of groups will be determined by the "knee point" on the graph. In this work we present a possible approach to this problem and show that our criterion equals the number of clusters with probability one for a sufficiently large sample. We assume that the random vector X has a multivariate mixture Gaussian model with k components. From a Bayesian perspective we introduce a penalized estimator to determine the number of groups, this estimator is based on the Krichevsky-Trofimov mixture distribution [3,4].

Acknowlegments: This work was produced as part of the activities of the Research, Innovation and Dissemination Center for Neuromathematics, grant FAPESP 2013/07699-0, FAPESP's project "Model selection in high dimensions: theoretical properties and applications", grant 2019/17734-3, São Paulo Research Foundation, Brazil; Rodrigues is supported by a CAPES scholarship and F. Leonardi was partially supported by a CNPq's research fellowship (309964/2016-4).

References

1. Pelleg, Dan and Moore, Andrew W and others: *X-means: Extending k-means with efficient estimation of the number of clusters.*, Icml, 1, 727–734 (2000).

2. Hancer, Emrah and Karaboga, Dervis: *A comprehensive survey of traditional, merge-split and evolutionary approaches proposed for determination of cluster number*, Swarm and Evolutionary Computation, 32, 49–67 (2017).

3. Cerqueira, Andressa and Leonardi, Florencia: *Estimation of the number of communities in the stochastic block model*, IEEE Transactions on Information Theory, 66, 10, 6403–6412 (2020).

4. Davisson, L and McEliece, R and Pursley, M and Wallace, Mark: *Efficient universal noiseless source codes*, IEEE Transactions on Information Theory, 27, 3, 269–279 (1981).

A Numerical Study of Bayesian Estimation of Context Trees

Arthur Reis Tabelini

Intitute of Mathematics and Statistics - University of São Paulo

In this work, we study and implement in the *Python* programming language bayesian methods for estimating Probabilistic Context Trees. Our main objective is to use bayesian inference on simulated data and compare the obtained results with those of the frequentist estimation, already largely used, and thus try to verify a better performance of the bayesian methods for “small” sample sizes. To that end, we are going to use exact inference, implementing the following algorithms: Bayesian Context Tree (BCT), Context Tree Weighting (CTW) and a MCMC sampler, using the descriptions present in Kontoyiannis et al (2022).

Keywords: Statistical inference, bayesian inference, exact inference, Variable Length Stochastic Chains, VLSC, BCT, CTW, Markov Chain Monte Carlo.

Acknowlegments: I thank my parents Douglas and Solange, my friends Cida and Víctor, my supervisor Aline and all the professors and employees of the Intitute of Mathematics and Statistics who contributted to my graduation.

Funding: This work was done as an undergraduate project of the Applied and Computational Mathematics course, and as such was supported by University of São Paulo.

References

1. Kontoyiannis, I. et al: *Bayesian context trees: Modelling and exact inference for discrete time series*, Journal of the Royal Statistical Society: Series B (Statistical Methodology) 84.4 , pp. 1287–1323 (2022).

2. Csiszár, I. and Talata, Z.: *Context Tree Estimation for Not Necessarily Finite Memory Processes, via BIC and MDL*, IEEE Transactions on Information Theory 52.3, pp. 1007–1016 (2006).

3. Rissanen, J.: *A Universal Data Compression System*, IEEE Transactions on Information Theory 29.5 , pp. 656–664 (1983).

4. Galves, A. et al: *Context tree selection and linguistic rhythm retrieval from written texts*, Annals of Applied Statistics 4.1, pp. 186–209 (2012).

5. Hernández, N. and Duarte, A.: *SeqROCTM: A Matlab toolbox for the analysis of Sequence of Random Objects driven by Context Tree Models*, CoRR abs/2009.06371 (2020).

Estimation of the Number of Communities in the Degree Corrected Stochastic Block Model

Cristel Vera Tapia

Programa Interinstitucional de Pós-Graduação em Estatística UFSCar-USP

The stochastic block model (SBM) is a random graph model that splits the set of vertices into groups, and the probability connection of each pair of vertices depends on the blocks to which the vertices belong. The SBM was introduced by [1] and it is traditionally applied to simple graphs, with each entry in the adjacency matrix following the Bernoulli distribution. [2] introduced the degree-corrected stochastic block model (DCSBM) that allows the degree distribution of vertices depending on the vertices and not just on the blocks they belong to. In this work, we address the problem of estimating the number of communities in the DCSBM. We consider the dense regime, where the probability of connection between pairs of vertices does not depend on the size of the graph, and the semi-sparse regime, with probability of connection between pairs of vertices decaying to zero with the size of the graph. In this general context, we prove that the estimator of the number of communities introduced by [3] (with the necessary changes) is strongly consistent.

Funding: This work was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) and as part of the activities of the Research, Innovation and Dissemination Center for Neuromathematics, grant FAPESP 2013/07699-0 and CNPq Universal Project 432310/2018-5.

References

1. Holland, P. W.; Laskey, K. B.; Leinhardt, S.: *Stochastic blockmodels: First steps*, Social networks, 5(2), 109–137, (1983).

2. Karrer, Brian and Newman, Mark EJ.: *Stochastic blockmodels and community structure in networks*, Physical review E, 83(1), 016107, (2011).

3. Cerqueira, A.; Leonardi, F.: *Estimation of the number of communities in the stochastic block model*, IEEE Transactions on Information Theory, (2020).

The asymptotic shape theorem for the frog model on finitely generated abelian groups

Cristian Favio Coletti

UFABC

In this poster we study the frog model on Cayley graphs of groups with polynomial growth rate $d \geq 3$. The frog model is an interacting particle system in discrete time. We consider that the process begins with a particle at each vertex of the graph and only one of these particles is active when the process begins. Each activated particle performs a simple random walk in discrete time activating the inactive particles in the visited vertices. We prove that the activation time of particles grows at least linearly and we show that in the abelian case with any finite generator set the set of activated sites has a limiting shape. This a joint work with Lucas R. de Lima.

Funding: This work was supported by Fapesp Grant No. 2017/10555-0

Semi-Parametric Non-Smoothing Optimal Dynamic Pricing

Daniele Bracale

University of Michigan

In this talk, we study a dynamic model where the market value of a product is linear in its observed features plus some market noise with unknown distribution F_0. Products are sold one at a time, and only the success or failure of the sale is observed. The goal is to post future prices to minimize the seller's regret. Under log-concavity of F_0 and $1 - F_0$, we estimate F_0 by non-parametric MLE and we implement a policy that achieves a better regret upper bound than [1]. We also determine the uniform convergence rate of the NPMLE under the log-concavity of F_0.

References

1. Fan, Jianqing and Guo, Yongyi and Yu, Mengxin: *Policy Optimization Using Semiparametric Models for Dynamic Pricing*, arXiv preprint arXiv:2109.06368 (2021).

The Dynamic Elephant Random Walk - DERW

Denis Araujo Luiz

Universidade Federal do ABC, Brazil

A random walk with unbounded memory is introduced as a mixture of the Elephant Random Walk and the Dynamic Random Walk which we call the Dynamic Elephant Random Walk (DERW). We prove a strong law of large numbers for the DERW and, in a particular case, we provide an explicit expression for its speed. Also, we give sufficient conditions for the Central Limit Theorem and the Law of the Iterated Logarithm to hold.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. Research

also supported by grants #2017/10555-0), #2019/19056-2, #2017/10555-0 and #2018/04764-9, São Paulo Research Foundation (FAPESP).

References

1. Coletti, C.F., de Lima, L.R., Gava, R.J. & Luiz, D.A.: *Limit theorems for a random walk with memory perturbed by a dynamical system*, Journal of Mathematical Physics, v. 61, n. 10, p. 103303, 2020.

2. Schütz, G.M. & Trimper, S.: *Elephants can always remember: Exact long-range memory effects in a non-Markovian random walk.*, Physical Review E, v. 70, n. 4, p. 045101, 2004.

3. Guillotin-Plantard, N. & Schott, R. *Dynamic Random Walks: Theory and applications.* Elsevier, 2006.

Probability minimization using Decison-Dependent Distributionally Robust Optimization

Diego Fonseca Valero

Universidad de los Andes

In this talk, we analyze the problem of minimizing the probability that a function does not exceed a given level where this function depends on a random vector and the decision. We study this via Distributionally Robust Optimization (DRO) approach using Wasserstein metrics where the ambiguity set depends on the decision. In contrast to other approaches in which the set of ambiguity does not depend on the decision, which triggers mixed integer programming problems [1,2], we show that for certain functions our resulting problem can be convex.

Acknowlegments: I thank Mauricio Junca for his contribution as co-author of this work.

Funding: This work was supported by Fondo de Investigaciones de la Facultad de Ciencias de la Universidad de los Andes INV-2022-137-2410 and INV-2021-126-2273.

References

1. Xie, Weijun: *On distributionally robust chance constrained programs with Wasserstein distance*, Mathematical Programming, 186, 1, 115–155 (2021).

2. Chen, Zhi and Kuhn, Daniel and Wiesemann, Wolfram: *Data-Driven Chance Constrained Programs over Wasserstein Balls*, Operations Research, 0, 0, (2022).

Change point detection in weighted networks based in global measures

Felipe Baptistão Durante Molina

Universidade Federal de São Carlos

Complex networks describe interactions between objects of study through graphs [1]. For instance, the objects of study in an air network are airports, that are represented by nodes in a graph, and the interactions between them, i.e., if there are flights between them, are represented by edges in a graph. Some social or socioeconomic events may influence changes in the structure of a network, changing the dynamics of interactions of an airport network through months and years. In that way, our objective is the study of the Brazilian air network over time. In our analysis, we have the objective of verifying if the pandemic of COVID-19 has caused changes in the structure of the network, due to travel restrictions that have been adopted since march 2020. In order to checking that, we will summarize some characteristics of the network using global weighted measures such as, *Strengh*, *Global Efficiency*, *Reciprocity* and *Average Shortest Path* to analyze them. The main goal is to determine if there has been changes in these measures over time, so this will be possible using change points detection to verify where there was a break in these metrics values.

Funding: This work was supported by grant #2021/14273-5, São Paulo Research Foundation (FAPESP).

References

1. Newman, Mark EJ. 2004. Analysis of weighted networks. *Physical review E*, **70**(5), 056131.

Conditional independence testing under model misspecification

Felipe Maia Polo

University of Michigan

Testing for conditional independence (CI) is a crucial and challenging aspect of contemporary statistics and machine learning. These tests are widely utilized in various areas, such as causal inference, algorithmic fairness, feature selection, and transfer learning. Many modern methods for conditional independence testing rely on powerful supervised learning methods to learn regression functions as an intermediate step. Although the methods are guaranteed to control Type I error when the supervised learning methods accurately estimate the regression function or Bayes predictor, their behavior when the supervised learning method fails due to model misspecification is not well understood. In this work, we study the performance of conditional independence tests based on supervised learning under model misspecification, i.e., we propose new approximations or upper bounds for the testing errors that explicitly depend on misspecification errors. Finally, we introduce the Rao-Blackwellized Predictor Test (RBPT), a novel CI regression-based test that is robust against model misspecification, i.e., compared with the considered benchmarks, the RBPT can control Type I error under weaker assumptions while maintaining non-trivial power.

Drift Estimation for the Generalized Langevin Equation with Lévy Jumps

Felipe S. Quintino

University of Brasilia-UnB

Issues concerning statistical estimation for the drift term of the generalized Langevin equation (GLE) are important to better fit the mathematical model to the potential real time series aimed to be modeled. They enable us to infer predictions on future matters of the modeled time series based on accumulated information. Statistical inference issues concerning the GLE also deserve attention to the relevance that such equation can play in modelling phenomena with memory effects. Based on joint work with A. Medino and C. Dorea ([1]), we present the maximum likelihood estimator (MLE) for the drift parameter of the GLE driven by a Lévy process observed continuously in time. Generally, the MLE has a non-explicit form and we propose a discretization of the MLE by filtering "big" jumps. A second discretized estimator is proposed using the same ideas as the former but introducing a path dependence of the simulated Lévy processes. Finally, estimations from simulated paths were done for the 3-parameter generalized Ornstein-Uhlenbeck process of the fluctuating exponential type.

Acknowlegments: I would like to thank Professors Chang Dorea and Ary Medino for their collaboration in work.

Funding: This work was supported by CAPES and CNPq.

References

1. Quintino, Felipe and Medino, Ary and Dorea, Chang: *Drift Estimation for a Class of Generalized Ornstein-Uhlenbeck Process with Fluctuating Exponential Trend*, preprint (2022).

Fractional Poisson random sum and its associated normal variance mixture

Gabriela Oliveira, Wagner Barreto-Souza and Roger W.C. Silva

Universidade Federal de Minas Gerais - UFMG

In this work, we study the partial sums of independent and identically distributed random variables with the number of terms following a fractional Poisson (FP) distribution. The FP sum contains the Poisson and geometric summations as particular cases. We show that the weak limit of the FP summation, when properly normalized, is a mixture between the normal and Mittag-Leffler distributions, which we call by Normal-Mittag-Leffler (NML) law. A parameter estimation procedure for the NML distribution is developed and the associated asymptotic distribution is derived. Simulations are performed to check the performance of the proposed estimators under finite samples. An empirical illustration on the daily log-returns of the Brazilian stock exchange index (`IBOVESPA`) shows that the NML distribution captures better the tails than some of its competitors.

Acknowlegments: G. Oliveira thanks the partial financial support from *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES-Brazil) and Instituto Federal de Minas Gerais (IFMG). W. Barreto-Souza acknowledges support for his research from the KAUST Research Fund and NIH 1R01EB028753-01.

Funding: Instituto Federal de Minas Gerais (IFMG).

Bayesian Conditional Transformation Model using Laplace Approximation.

Giovanni Pastori Piccirilli; Marcia D'Elia Branco

Departamento de Estatística, IME, Universidade de São Paulo

We propose an alternative estimation method based on the Integral Nested Laplace Approximation (INLA) [5] for the Bayesian Conditional Transformation Models (BCTM) [2]. The BCTM is a Bayesian approach for the Conditional Transformation Models (CTM) [3]. The CTM extends the transformation models class allowing transformation functions to be function of explanatory variables. The CTM is given by $P(Y \leq y|\boldsymbol{X} = \boldsymbol{x}) = P(h(Y|\boldsymbol{x}) \leq h(y|\boldsymbol{x})) = F_Z(h(y|\boldsymbol{x}))$, where $h(y|\boldsymbol{x})$ is the conditional transformation function, and F_Z is the continuous baseline distribution. These new transformation functions (conditional on explanatory variables) with the pre-defined conditional distribution F_Z allow the evaluation of the conditional distribution function of the response variable given the explanatory variables. Some restrictions about $h(y|\boldsymbol{x})$ should be imposed. Its construction range between loss-complex and low-parameterized functions, similar to simple linear regression models, to complex relationships between explanatory variables and response represented by non-linear functions. To achieve a complex structure we are expressing $h(y|\boldsymbol{x})$ as linear combination of basis function. A flexible basis used for $c_j(y|\boldsymbol{x})$ is the B-spline basis function. The B-spline basis choice comes from a well-presented monotone increasing parameterization, enough flexibility, and an interesting result termed P-spline in which a difference penalty is employed to overcome the underfitting and overfitting problems. Some characteristics of the model impede us to use directly the *INLA* R package, requiring the implementation of our algorithm. To show the quality of the algorithm proposed, we considered three applications. The first two applications are already presented in the [3] using the *mlt* R package. The last application considered the Framingham Heart Study dataset [2].

Funding: This work was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES).

References

1. M. Carlan and T. Kneib. Bayesian discrete conditional transformation models. *Statistical Modelling*, page 1471082X221114177, 2022.

2. M. Carlan, T. Kneib, and N. Klein. Bayesian conditional transformation models. *Journal of the American Statistical Association*, (just-accepted):1–24, 2023.

3. T. Hothorn, T. Kneib, and P. Bühlmann. Conditional transformation models. *Journal of the Royal Statistical Society: Series B: Statistical Methodology*, pages 3–27, 2014.

4. Bühlmann]hothorn2018most T. Hothorn, L. Möst, and P. Bühlmann. Most likely transformations. *Scandinavian Journal of Statistics*, 45(1):110–134, 2018.

5. H. Rue, S. Martino, and N. Chopin. Approximate bayesian inference for latent gaussian models by using integrated nested laplace approximations. *Journal of the royal statistical society: Series b (statistical methodology)*, 71(2):319–392, 2009.

Bayesian Dynamic Processes to Estimate Mortality Schedules in Small Areas

Guilherme Lopes de Oliveira

Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG)

The reliable measurement and comparative analysis of mortality schedules for different populations are helpful to highlight differences among groups of people and guide analysts to understand what drives health disparities. For developing countries, especially in subnational geographic populations that do not have the resources to establish reliable death registration, the incorporation of empirical information is an interesting approach to improve the mortality estimates provided by usual parametric models. The problem with data coming from small and underdeveloped populations is the high occurrence of low or null counts, which impairs the estimation of the true underlying mortality rates by usual methods. In this work, we present a discussion about this problem and introduce the use of relational Bayesian dynamic processes for estimating and smoothing mortality schedules by age and sex [1]. Inference is made under the Bayesian paradigm. Preliminary results are presented, including a comparison with the TOPALS model [2], a methodology commonly applied in demography field. The analysis are based on simulated data as well as mortality data observed in some Brazilian municipalities. This is a joint work with Rosangela Helena Loschi (DEST/UFMG) and Renato Martins Assunção (DCC/UFMG).

Funding: G.L.O. thanks DPPG/CEFET-MG for financial support. R.L.H. and R.M.A. also thanks FAPEMIG and CNPq for their partial support.

References

1. Oliveira, G.L., Loschi, R.H. and Assunção, R.M.: *Bayesian Dynamic Estimation of Mortality Schedules in Small Areas*, Available at arXiv (stat.ME), arXiv:2105.02203 (2022).

2. Gonzaga, M.R. and Schmertmann, C.P.: *Estimating age- and sex-specific mortality rates for small areas with TOPALS regression: an application to Brazil in 2010*, Revista Brasileira de Estudos de População, 33, 3, 629–652 (2016).

The coverage ratio of the frog model on complete graphs

Gustavo Oshiro de Carvalho

Universidade de São Paulo

We consider a system of interacting random walks known as the frog model on complete graphs. Initially, an active particle is placed at one vertex of the $n-$complete graph $\mathcal{K}_n$, as well as one inactive particle at each other vertex. At each instant of time, each active particle may die with probability $1-p$. Every active particle performs a simple symmetric random walk on $\mathcal{K}_n$ until the moment it dies, activating all inactive particles it hits along its path.

In this talk, we study the limit in n of the proportion of visited vertices until all active particles have died.

Funding: This work was supported by Capes (88887.676435/2022-00), CNPq (303699/2018-3 and 132598/2020-5) and FAPESP (17/10555-0).

Ratio process of multi-type branching processes with immigration

Imanol Nuñez

CIMAT

In [1] the authors studied, among other things, the frequency process of two, possibly asymmetric, continuous-state branching processes with immigration under the assumption of independence. In this talk we present an extension when the branching processes are not necessarily independent, and recent progress when there are three or more independent branching processes.

Acknowlegments: I want to thank J. L. Pérez for introducing me to the subject, his guidance through branching processes literature and the useful discussions that led to this work.

References

1. Caballero, M. E., González Casanova, A., Pérez, J. L.: *The relative frequency between two continuous-state branching processes with immigration and their genealogy.*, *Preprint arXiv:2010.00742*, (2020).

Recent results about Hilbert embeddings of probabilities.

Jean Carlo Guella

Imecc-Unicamp

We review some recent theoretical results about Hilbert space embeddings of probabilities, like the fact that Gaussian kernels on Hilbert spaces define an inner product in the space of measures with bounded variation and that the standard metric in Hilbert and real/complex hyperbolic spaces are of the strong negative type. We also present the concept of positive definite independent kernels, which generalizes the concepts of Hilbert Schmidt Independence Criterion and Distance Covariance, provides a metric in the space of couplings, and are related to Bernstein functions with 2 variables.

Funding: Fapesp Young investigator 2021/04226-0 and 2022/00008-0

References

1. Lyons, Russell: *Distance covariance in metric spaces*, Annals of Probability, 5, 41 3284–3305 (2013).
2. Guella, Jean Carlo: *On Gaussian kernels on Hilbert spaces and kernels on Hyperbolic spaces*, Journal of Approximation Theory, 279, (2022).
3. Guella, Jean Carlo: *Generalization of the energy distance by Bernstein functions* , Journal of Theoretical Probability (2022).
4. Guella, Jean Carlo: *Generalization of the HSIC and distance covariance using positive definite independent kernels*,(2022).

From stochastic hamiltonian systems to stochastic compressible Euler equation

Jesus Manuel Correa Lora

Instituto de Matemática, Estatística e Computação Científica

For all $N \in \mathbb{N}$ we consider N particles in $\mathbb{R}^d$ where the position $X_t^{k,N}$ verifies for $k = 1, \cdots, N$

$$d^2 X_t^{k,N} = -\frac{1}{N} \sum_{l=1}^{N} \nabla \phi_N \left(X_t^{k,N} - X_t^{l,N} \right) dt + \sigma \left(X_t^{k,N} \right) \frac{dX_t^{k,N}}{dt} \circ dB_t \tag{2}$$

where $\{B_t^i)_{t\in[0,T]},\ i \in \mathbb{N}\}$ is a family of standard $\mathbb{R}^d$-valued Brownian motions defined on a filtered probability space. Our aim is the study of the asymptotics as

$N \to \infty$ of the time evolution of the whole system of all particles. Therefore, we investigate the empirical processes :

$$S_t^N :\, = \frac{1}{N} \sum_{k=1}^{N} \delta_{X_t^{k,N}}, \tag{3}$$

$$V_t^N :\, = \frac{1}{N} \sum_{k=1}^{N} V_t^{k,N} \delta_{X_t^{k,N}} \tag{4}$$

where $dX_t^{k,N} :\, = V_t^{k,N} dt$ is the velocity of the kth particle, and δ_a, denotes the Dirae measure at a. We shall prove that S_t^N and V_t^N converge as $N \to \infty$ to solutions of the continuity equation and the stochastic Euler equation, respectively.

Acknowlegments: I thank God because he has been my guide for my grandparents and my parents, for always supporting me

Funding: This work was supported by CNPq through the grant 141464/2020-8.

Effective connectivity between stochastic neurons

João Victor Russo Izzi

Federal University of São Carlos

Identify the connections that defines the neural circuity is essential to explain how the neural network will behave in new situations. In this work, we are interested in the application of some descriptive measures in detecting the connection between neurons draw from a stochastic source and quantifying the amount of single-directional information which flows from one neuronal spike train to another. In particular, we consider the neuronal activity draw from Markov chains with full memory and Markov chains with variable length memory and we compare the performance of these descriptive measures in these scenarios from simulated examples.

Acknowlegments: I thank Prof. Dr. Ricardo Felipe Ferreira, my academic advisor, who has helped and taught me a lot throughout the execution of this project.

Funding: This work was supported by grant #2022/10524 − 6 São Paulo Research Foundation (FAPESP).

References

1. GERSTNER, W.; KISTLER, W. M.; NAUD, R. AND PANINSKI, L.: *Neuronal Dynamics.* Cambridge University Press. (2014)

2. I. M.; YOSHIMOTO, J. AND DOYA, K.: *Connectivity inference from neural recordings data: challenges, mathematical bases and research directions.* Neural Networks. (2018).

3. GALVES, A. AND LOCHERBACH, E.: *Modeling networks of spiking neurons as interacting process with memory of variable length.* Jounal de la société de statistique, vol. 157, no. 1, pp. 17-32. (2016).

4. CORDEIRO, V. L.; PENA, R. F. O.; CEBALLOS, C. A. C.; SHIMOURA, R. O. AND ROQUE, A. C.: *Aplicações da teoria da informação à neurociência.* Revista Brasileira de Ensino da Física, vol. 41, no. 2, e20180197. (2019).

Mean-Field Games with Common Poissonian Noise

Joshué Helí Ricalde Guerrero

CIMAT- Centro de Investigación en Matemáticas

Mean-Field Games arise as limit problems of symmetric stochastic differential games and their equilibriums, where the coupling between players is only due to statistics of the population. It was later proposed to strengthen this coupling by adding a common Gaussian process to the individual dynamics. These are the so-called Mean-Field Games with Common Noise. In this talk we propose adding a pure jump martingale process instead of a Brownian motion for the Common noise. Furthermore, we consider the case when the stochastic intensity is driven by the statistical characteristics of the population, as well and derive the corresponding Stochastic Hamiltonian System along with a stochastic version of Pontryagin's Maximum Principle.

Funding: This work was supported by the National Council of Science and Technology CONACyT, scholarship number 863210.

Rate of convergence of N-player Games of Moderate Interactions to the associated MFG PDEs.

Josué Knorst

University of Campinas

We consider the N-player game where each player $i \in [[N]]$ has position given by

$$dX_t^{N,i} = \Big(\alpha^{N,i}(t) + b\big(X_t^{N,i}, \frac{1}{N}\sum_{j=1}^{N} V^N(X_t^{N,i} - X_t^{N,j})\big)\Big)dt + dW_t^{N,i},\ t \in [0,T].$$

where $\alpha^N = (\alpha^{N,1}, ..., \alpha^{N,N})$ is a vector of strategies, b is deterministic and $W^{N,i}$ are independent Wiener processes. Each player acts to minimize a certain functional over $[0,T]$. This setting is considered in [1], where they prove the minimum is attained by $\alpha^*(t,x) \doteq -\nabla u(t,x)$ (see (1)). The mollified empirical measure $p^N \doteq V^N * S^N$, where $S_t^N \doteq \frac{1}{n}\sum_i \delta_{X_t^{N,i}}$ converges to the density p, where (u,p) is the solution of the associated MFG system of PDEs

$$\begin{cases} -\partial_t u - \frac{1}{2}\Delta u - b(x,p(t,x)) \cdot \nabla u + \frac{1}{2}|\nabla u|^2 = f(x,p(t,x)), & (t,x) \in [0,T) \times \mathbb{R}^d, \\ \partial_t p - \frac{1}{2}\Delta p + \mathrm{div}[p(t,x)(-\nabla u(t,x) + b(x,p(t,x)))] = 0, & (t,x) \in (0,T] \times \mathbb{R}^d, \\ p(0,\cdot) = p_0(\cdot), \quad u(T,\cdot) = g(\cdot), & x \in \mathbb{R}^d. \end{cases} \tag{5}$$

Using the approach of [3], we prove the following rate of convergence. For every $\epsilon > 0$, $m \geq 1$, and $q \in [1,\infty)$, we have

$$\big\| \, \|p^N - p\|_{T,L^q(\mathbb{R}^d)} \big\|_{L^m(\Omega)} \leq C \big\| \, \|p^N(0,\cdot) - p_0\|_{L^q(\mathbb{R}^d)} \big\|_{L^m(\Omega)} + CN^{-\rho+\epsilon},$$

with
$$\rho \doteq \min\left(\frac{\beta}{d}\gamma \wedge \gamma', \frac{1}{2}(1 - \beta(1+\theta_q))\right),\ \theta_q \doteq \left(1 - \frac{2}{q}\right) \vee 0$$

and γ, γ' are the Hölder regularity of $\alpha = -\nabla u$ and all p^N, respectively.
$\beta \in (0, \frac{1}{2})$ expresses the moderate interaction.

Acknowlegments: This is a joint work with Alexandre B. de Souza and Christian Olivera.

Funding: This work is supported by FAPESP Thematic Project 2020/04426-6 and FAPESP Post-doctoral Project 2022/13413-0.

References

1. Flandoli, Flanco, Ghio, Maddalena, and Livieri, Giulia: *N-Player Games and Mean Field Games of Moderate Interactions*, Applied Mathematics & Optimization, 85:38 (2022).

2. Knorst, Josué, Olivera, Christian, and Souza, Alexandre B.: *Rate of convergence of N-player Games of Moderate Interactions to the associated MFG PDEs.*, in preparation.

3. Olivera, Christian, Richard, Alexandre, and Tomašević, Milica: *Quantitative particle approximation of nonlinear Fokker-Planck equations with singular kernel.*, Ann. Sc. Norm. Super. Pisa Cl. Sci (accepted), 2021.

Euler-Lagrangian approach to stochastic Euler equations in Sobolev Spaces

Juan David Londoño Acevedo

Universidade Estadual de Campinas

In this talk i establish the equivalence between Lagrangian and classical formulations for the stochastic incompressible Euler equations, the proof is based in Ito-Wentzell-Kunita formula and stochastic analysis techniques. Moreover, we prove a local existence result for the Lagrangian formulation in suitable Sobolev Spaces.

Funding: This work was supported in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001- on behalf of the first-named author. The second author is funded by the grant $2020/15691-2$ and $2020/04426-6$, São Paulo Research Foundation (FAPESP)

References

1. F. Flandoli, D. Luo,: *Euler-Lagrangian approach to 3D stochastic Euler equations*, Journal of Geometric Mechanics, 18, (2019).
2. P.Constantin, and G. Iyer,: *A stochastic Lagrangian representation of the three-dimensional incompressible Navier-Stokes equations*, 61, (2008).
3. B. Pooley, J. Robinson,: *An Eulerian-Lagrangian form for the Euler equations in Sobolev spaces*, J. Math. Fluid Mech., 18, (2016).
4. C. Olivera: *Probabilistic representation for mild solution of the Navier–Stokes equations*, Mathematical Research Letters, 28, (2021).

Look-down construction for a Moran Seed-Bank Model: Results in probability for the time to most common recent ancestor and fixation time.

Julio Ernesto Nava Trejo

Facultad de Ciencias, UNAM

In this talk, I will address a modified version of a Moran model with seed-banks which will allow me to propose and ordered particle system in the setting of classical look-down constructions [1,3]. I will delve into how the framework of look-down models enable us to relate the time to common ancestor [2], with the largest inactivity period in the coalescent, showing that their ratio tends to 1 in probability.

Additionally, we will study the long-term behavior of the largest inactivity period. Finally, I will translate this results to the fixation time of a type in the particle system.

Acknowlegments: I thank María Clara Fittipaldi and Adrián González Casanova for this on going joint work and all the guidance.

References

1. Blath, J., González Casanova, A., Kurt, N. & Wilke-Berenguer, M. A new coalescent for seed-bank models. *The Annals Of Applied Probability.* **26**, 857-891 (2016)

2. Donnelly, P. & Kurtz, T. A countable representation of the Fleming-Viot measure-valued diffusion. *The Annals Of Probability.* **24**, 698 - 742 (1996), https://doi.org/10.1214/aop/1039639359

3. Etheridge, A. & Kurtz, T. Genealogical constructions of population models. *The Annals Of Probability.* **47**, 1827 - 1910 (2019), https://doi.org/10.1214/18-AOP1266

Estimating the number of communities in weighted networks

Luana Ayumi Tamura

Universidade Federal de São Carlos - UFSCar

The Stochastic Block Model is a commonly used model in real networks that exhibits community structure, that is, the vertices of the network are divided into groups. However, the number of communities related to the underlying model is not specified in real data, so it is necessary to use inferential methods to estimate this number. The objective of this work is to study the method proposed by [1] to estimate the number of communities for binary networks. Moreover, we will adapt this method to estimate the number of communities in weighted networks.

Acknowlegments: I thank my advisor Andressa Cerqueira for help and guidance in the development of the research, my friends Gustavo, Luben, Paulo, Rodrigo and Vicenzo for help and support.

Funding: This work was supported by in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and by the Programa Interinstitucional de Pós-Graduação em Estatística UFSCar-USP (PIPGEs).

References

1. Jing Lei: *A goodness-of-fit test for stochastic block models*, The Annals of Statistics, 1, 44, 401–424 (2016).

Toward Local and Valid Uncertainty Estimation in Machine Learning

Luben Miguel Cruz Cabezas, Mateus Piovezan Otto, Rafael Izbicki, Rafael Bassi Stern

Federal University of São Carlos / University of São Paulo

Predictive models make mistakes, and thus it is often important to quantify the uncertainty associated with their predictions. Recently, conformal inference emerged as a powerful tool in creating statistically valid prediction regions. However, the application of conformal machinery to prediction methods yields sub-optimal regions that are not adaptive. Researchers have overcome this by designing new conformal scores. Although they are useful in creating prediction bands, these are detached from the original goal of transforming simple point predictions into prediction intervals and use more complicated base models to generate prediction regions such as quantile regression methods and conditional density estimators. In this work, we focus on improving the existing conformal regression split method. We develop a framework capable of generating locally adaptative prediction intervals using decision tree-based feature space partitions. We compare our method to other adaptative approaches, such as the locally weighted conformal split and Mondrian conformal split.

Acknowlegments: I thank my advisor Rafael Izbicki and co-advisor Rafael Bassi Stern for the constant help and supervision on this work and my colleague Mateus Piovezan Otto for the discussion of ideas and help in the code implementation.

Funding: This work was supported by FAPESP, grant 2022/08579-7.

References

1. Izbicki, Rafael and Shimizu, Gilson and Stern, Rafael B.: *Distribution-free conditional predictive bands using density estimators*, Proceedings of AISTATS 2020, v 108, p 3068-3077 (2020).

2. Lei, Jing and G'Sell, Max and Rinaldo, Alessandro and Tibshirani, Ryan J and Wasserman, Larry: *Distribution-free predictive inference for regression*, Journal of the American Statistical Association, v 113, n 523, p 1094–1111 (2018)

3. Papadopoulos, Harris and Vovk, Vladimir and Gammerman, Alexander: *Algorithmic learning in a random worlde*, Springer Science & Business Media (2005).

Population-based change-point detection for the identification of homozygosity islands

Lucas de Oliveira Prates

Institute of Mathematics and Statistics - University of São Paulo

In this talk we will present the main results in . we will discuss the problem of identifying homozygosity islands on the genome of individuals in a population. We present a method that directly tackles the issue of identification of the homozygosity islands at the population level, without the need of analysing single individuals and then combine the results. We propose regularized offline change-point methods to detect changes in the parameters of a multidimensional distribution when we have several aligned, independent samples of fixed resolution. We present a penalized maximum likelihood approach that can be efficiently computed by a dynamic programming algorithm or approximated by a fast binary segmentation algorithm. Both estimators are shown to converge almost surely to the set of change-points without the need of specifying a priori the number of change-points. In simulation, we observed similar performances from the exact and greedy estimators. Moreover, we provide a new methodology for the selection of the regularization constant which has the advantage of being automatic, consistent, and less prone to subjective analysis.

Acknowlegments: I thank Florencia Leonardi, Renan B. Lemes and Tábita Hünemeier for the collaboration in the paper.

Funding: This work was supported by the São Paulo Research Foundation, Brazil [2013/07699-0, 17/10555-0, 20/10136-0, 21/06860-8]; Coordination of Superior Level Staff Improvement, Brazil [Ph.D. fellowship to Lucas Prates]; and the National Council for Scientific and Technological Development, Brazil, [311763/2020-0 to Florencia Leonardi].

References

1. Prates, Lucas and Lemes, Renan B and Hünemeier, Tábita and Leonardi, Florencia: *Population-based change-point detection for the identification of homozygosity islands*, Bioinformatics, 39, 4, pg.—(2023).

Estimation and model selection for mixing graphical models

Magno Tairone de Freitas Severino

University of São Paulo

In this work, which is part of my Ph.D. dissertation, we propose a global model selection criterion to estimate the graph of conditional dependencies of a random vector, whose distribution corresponds to the stationary distribution of a mixing stochastic process. By global criterion we mean the optimization of a function over the set of possible graphs, without the need of estimating the individual neighborhoods and then combining the results, as proposed in [1]. We prove the consistency of the approach and propose a simulated annealing efficient algorithm to estimate the graph of conditional dependencies as well as the parameters of the model.

Acknowlegments: Many thanks to Florencia Leonardi for her invaluable contribution and feedback during the development of this project.

Funding: This work was partially funded by CAPES, CNPq and FAPESP.

References

1. Leonardi, F. & Carvalho, R.: Structure recovery for partially observed discrete Markov random fields on graphs under not necessarily positive distributions, arXiv, (2019), `https://arxiv.org/abs/1911.12198`

Microsurvey on Gallai's Conjecture: Decomposition of graphs

Marco Antonio Ticse Aucahuasi

Universidade Federal de Minas Gerais

The problem of decomposition of graphs by partitioning its set of edges with a minimum number of subgraphs has been studied by several authors in recent years. In this field, Gallai conjecture (1966) states that every connected graph with n vertices admits a path decomposition of size at most $\lfloor \frac{n+1}{2} \rfloor$. This conjecture became relevant and was demonstrated for certain types of graphs, however it is still an open problem. In this poster we present a microsurvey of the Gallai conjecture. To this end, we start with Lovász [1] and distinguish Schwartz [2] considering simple and random graphs.

Acknowlegments: I thank the Department of Statistics and Mathematics of the Institute of Exact Sciences of the University of Minas Gerais.

Funding: This work was supported by The Research Support Foundation of the State of Minas Gerais (FAPEMIG)

References

1. Lovász, Lazlo: *On covering of graphs*, Theory of Graphs (Proc. Colloq., Tihany, 1966), 231-236 (1968).

2. SCHWARTZ, STEPHAN: *An overview of graph covering and partitioning*, Discrete Mathematics, 345, 8, 17 (2022).

Jump detection in high-frequency financial data using wavelets

Mateus Gonzalez de Freitas Pinto

Institue of Mathematics and Statistics - Univesity of São Paulo

The presence of spikes or cusps in high-frequency return series might generate problems in terms of inference and estimation of the parameters in volatility models. For example, the presence of jumps in a time series can influence sample autocorrelations, which can cause misidentification or generate spurious ARCH effects. On the other hand, these jumps might also hide relevant heteroskedastic behavior of the dependence structure of a series, leading to identification issues and a poorer fit to a model. In this poster contribution, we propose a wavelet-shrinkage method to separate out jumps in high-frequency financial series, fitting a suitable model that accounts for its stylized facts. We also perform simulation studies to assess the effectiveness of the proposed method, in addition to illustrating the effect of the jumps in time series. Lastly, we use the methodology to model real high-frequency time series of stocks traded on the Brazilian Stock Exchange and OTC and a series of cryptocurrencies trades.

Acknowlegments: I thank my co-authors Chang Chiann and Guilherme de Oliveria Lima C. Marques for their support and contribution to the paper

Funding: my co-author Chang Chiann would like to acknowledge the partial support of FAPESP through the grant 2018/04654-9

References

1. PINTO, MATEUS GONZALEZ DE FREITAS AND MARQUES, GUILHERME DE OLIVERIA LIMA CAGLIARI AND CHIANN, CHANG: *Jump detection in high-frequency financial data using wavelets*, International Journal of Wavelets, Multiresolution and Information Processing, 21, 02, 2250056 (2023).

RFFNet: Scalable and Interpretable Kernel Methods based on Random Fourier Features

Mateus P. Otto, Rafael Izbicki

Federal University of São Carlos

Kernel methods provide a flexible and theoretically grounded approach to nonlinear and nonparametric learning. While memory requirements hinder their applicability to large datasets, many approximate solvers were recently developed for scaling up kernel methods, such as random Fourier features [1]. However, these scalable approaches are based on approximations of isotropic kernels, which are incapable of removing the influence of possibly irrelevant features. In this work, we design random Fourier features for automatic relevance determination kernels [2], widely used for variable selection in gaussian processes, and propose a new method based on joint optimization of the kernel machine parameters and the kernel relevances. Additionally, we present a new optimization algorithm that efficiently tackles the resulting objective function, which is highly non-convex. Numerical validation on simulated and real-world data shows that our approach has a small memory footprint, achieves low prediction error, and effectively identifies relevant predictors, thus leading to more interpretable solutions. Our solution is modular and uses the PyTorch framework.

Acknowlegments: I thank Julio Michael Stern and Roberto Imbuzeiro Oliveira for helpful suggestions during the elaboration of this work.

Funding: MPO acknowledges financial support through grant 2021/02178-8, São Paulo Research Foundation (FAPESP). RI acknowledges financial support through grants 309607/2020-5 and 422705/2021-7, Brazilian National Counsel of Technological and Scientific Development (CNPq), and grant 2019/11321-9, São Paulo Research Foundation (FAPESP).

References

1. Rahimi, Ali and Recht, Ben: *Random features for large-scale kernel machines*, Advances in Neural Information Processing Systems 20 (NIPS 2007), 1177-1184 (2008).

2. Rasmussen, Carl Edward and Williams, Christopher K. I.: *Gaussian Processes for Machine Learning*, The MIT Press, 2005

About the design of a didactic sequence on Law of Large Numbers and Central Limit Theorem for undergraduate level

Nicolas Igolnikov

Universidad de Buenos Aires

In this talk, I will share and discuss the results of a research made in the context of my graduate thesis on Mathematics, around the title of this topic. The core idea was, starting with a research on the historical development of the problem of inferring the probability of an event, and of proposing a distribu- tion of the observational errors of an unbiased instrument, make a didactical- mathematical study of probability and statistical theory that gives better condi- tions to adapt these problems to an actual classroom, taking in mind the global design that is necessary to make possible that implementation.

Acknowlegments: I thank to Mariela Sued and Carmen Sessa for both di- recting and codirecting this thesis, and to all of the support of the Mathematics Department of the University of Buenos Aires, allowing and encouraging me to do it

Kolmogorov-Smirnov test for high dimensional data based on selecting projection

Noslen Hernández*

Institut National Polytechnique de Toulouse
*In collaboration with Zitlalli Salas and Rolando J. Biscay

The rapid advancement of technology and measurement devices has enabled the recording of a vast array of features pertaining to an object of study. For such high dimensional data, classical, low dimensional multivariate statistical techniques are not applicable. Consequently, the high dimension of modern big data presents challenges not only in its computational aspects but also in statistical theory. As a contribution in this topic, this work presents a novel approach to distributional-free hypothesis testing for high-dimensional data. Specifically, we propose a novel test for the hypothesis problem of whether two high dimensional samples share the same distribution or not. A few methods have been proposed to address this problem. These include norm or distance-based techniques and graph- based methods, which have the disadvantage of approximating the decision thresholds through permutations of the samples that have high computational cost or through asymptotic limits that require a large sample size. Another category of methods is based on random projection. This involves projecting the data onto a randomly generated direction, so reducing the dimensionality of the data by transforming it into univariate data, and then applying the univariate Kolmogorov-Smirnov test to the projected data. This approach utilizes exact thresholds but have the drawback of exhibiting low power in many scenarios where the differences between the compared distributions are primarily concentrated in a low dimensional sub-region of the sample space. The introduced approach is based on projecting the data on a convenient, data-driven selected direction instead of on a random direction and applying the univariate Kolmogorov- Smirnov (KS) test to the resulting projected data. Its performance is illustrated in comparison with other methods in a variety of data settings comprising different distributions and dimension sizes.

Transfer entropy rate estimation and stationary variable length bivariate Markov chains

Ricardo Felipe Ferreira

Federal University of São Carlos

Transfer entropy and the transfer entropy rate are closely related concepts that quantifies the amount of single-directional information which flows from one random sequence to another. These measures allow us to study linear and nonlinear causality relations between discrete random processes. In this work, we are interested in estimating the transfer entropy between a pair of jointly stationary variable length Markov chains. We consider the plug-in estimator of transfer entropy and study its properties. In particular, we compare some of these properties with that obtained from the transfer entropy estimation between a pair of jointly stationary full Markov chains.

Acknowlegments: I thank Dr. Daniel Y. Takahashi for discussions about the transfer entropy estimation problem.

Funding: This work was partially supported by grants #16/12918−0 and #18/25076−3 São Paulo Research Foundation (FAPESP).

References

1. Antos, A. and Kontoyiannis, I.: *Convergence properties of functional estimates for discrete distributions*, Random Structures and Algorithms, vol. 19, no. 3-4, 163-193(2001).

2. Bühlmann, P. and Wyner, A. J.: *Variable length Markov chains*, The Annals of Statistics, vol. 27, no. 2, 480-513 (1999).

3. de Assis, J. M. and de Assis, F. M.: *Estimation of transfer entropy between discrete and continuous random process*, Journal of Communication and Information Systems, vol. 33, no. 1, 1-11(2018).

4. Ferreira, R. F.: *Concentration bounds for plug-in estimator of directed information*, IEEE Transactions on Information Theory, vol. 67, no. 8, 4939-4947 (2021).

Local Influence for Partially Linear Spatial Regression Models

Rodolpho Jórdan Domingos Quintela

Institute of Mathematics and Statistics of the University of São Paulo

This work presents two-dimensional modeling for Geostatistical analysis, considering partially linear spatial regression models (PLSMs), using the Thin Plate Spline (TPS) method to fit a surface to data in a multidimensional space and aims to propose measures for the diagnostic analysis, focusing on measures for local influence analysis. For this, we derived such measures based on extensive bibliographic and conceptual research on this method in the context of PLSMs. This technique was used in examples of application to real data and the results were discussed in order to evaluate our theoretical study. Therefore, we present the estimation equations for the model parameters through the penalized likelihood function, considering the use of TPS as a nonparametric structure, as well as the measures for the analysis of local influence based on Cook's theory defined in the context of nonparametric regression.

Acknowlegments: I thank to my family and friends. To my advisor Prof. doctor Gilberto A. Paula for his patience and for always being so helpful in clarifying any doubts about the development process of this work.

Funding: This work was supported by CAPES.

References

1. BOOR, C. D.: *A practical guide to splines*, Springer, 1978.
2. WOOD, S. N.: *Generalized Additive Models: an Introduction with R.*, CRC Press, 20017.
3. COOK, R. D: *Assessment of local influence.*, Journal of the Royal Statistical Society - Series B (Methodological), 1978.
4. LEE, S.-Y., LU, B. AND SONG, X.-Y: *Assessing local influence for nonlinear structural equation models with ignorable missing data.*, Computational statistics & data analysis,Elsevier, v. 50, n. 5, p. 1356–1377, 2006. 2006.

Normal scale mixture copula marginal regression with Box-Cox symmetric distributions

Rodrigo Matheus Rocha de Medeiros and
Silvia Lopes de Paula Ferrari

Department of Statistics, University of São Paulo, São Paulo, Brazil

This work introduces a broad class of marginal regression models for analyzing correlated positive data with Box-Cox symmetric marginal distributions. The dependence is described by a normal scale mixture copula, offering a fully-parametric alternative to the classical generalized estimating equation models. The proposed class provides a flexible modeling framework for positive data with different levels of skewness and tail-heaviness, allowing for different dependence structures, including independence, time series, longitudinal, clustered, or spatially correlated data through the use of the copula. We propose likelihood-based inference for parameter estimation, define residuals for diagnostic analysis, and discuss an application with spatial data.

Funding: financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 and by the Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brazil (CNPq)

References

1. Ferrari, S. L. P., and Fumes, G.: *Box–Cox symmetric distributions and applications to nutritional data*, Journal's AStA Advances in Statistical Analysis, 101, 321–344 (2017).

2. Masarotto, G., and Varin, C.: *Gaussian copula marginal regression*, Electronic Journal of Statistics, 6, 1517–1549 (2012).

A systematic literature review about run orders in factorial designs

Romario Conto-López

Instituto Tecnológico Metropolitano

Alexander Correa-Espinal

Universidad Nacional de Colombia

Olga Úsuga-Manco

Universidad de Antioquia

In this paper we show the results of a systematic literature review (SLR) about the importance of run orders in factorial experiments. In this SLR we did a taxonomic division of the papers found about the topic in the period 1952-2021. As a result of this review, we describe the main findings, main research directions and opportunities and show that it has not yet been possible to find execution orders with

minimum bias and minimum level changes for designs with any number of factors and levels.

Probabilistic and Statistical Modelling through Some Elements of Differential Geometry.

Saulo Henrique Furtado Leite

University of Brasilia (UnB)

This work refers to the ongoing master dissertation project that the author has been developing as a student of the Graduate Program in Mathematics at the University of Brasilia under the supervision of the professor Ary Vasconcelos Medino.

In the project, we deal with statistical manifolds, Fisher information metric, Fisher-Rao distance between two probability distributions, Fisher information matrix, Kullback-Leibler divergence, the Cramer-Rao theorem, as well as relations among these topics and the geometry of the hyperbolic space.

In this work, we present preliminary results from the aforementioned research project.

Acknowlegments: To the Graduate Program in Mathematics at the University of Brasilia and the "Fundação de Apoio a Pesquisa do Distrito Federal (FAPDF)" for all support to the realization of this project.

Funding: This work has been supported by "Fundação de Apoio a Pesquisa do Distrito Federal (FAPDF)".

References

1. Calin, O.; Udriste, C.: *Geometric Modeling in Probability and Statistics*. In Mathematics and Statistics; Springer International: Cham, Switzerland, 2014.

2. Costa, S.I.R.; Santos, S.A.; Strapasson, J.E.: *Fisher information distance: A geometrical reading*, Discret. Appl. Math., 197, 59–69 (2015).

3. Atkinson, C.; Mitchell, A.F.S. *Rao's Distance Measure*, Sankhyã Indian J. Stat., 43, 345–365 (1981).

4. Angulo, J.; Velasco-Forero, S.: *Morphological processing of univariate Gaussian distribution-valued images based on Poincaré upper-half plane representation.* In Geometric Theory of Information; Springer International Publishing: Cham, Switzerland; pp. 331–366 (2014).

Efficient posterior sampling for multivariate spatial count models

Sergio Henrique Andrade de Azevedo

Universidade Estadual de Campinas- IMECC

In general, spatial statistics methods require using dense covariance matrices that need careful approaches to general scalability, a problem which is exacerbated in the multivariate and/or spatio-temporal context. One way of easening the computational burden is to induce sparsity while preserving the positive-definiteness of the covariance matrix, the covariance tapering method achives both by relying on a compact-supported function called taper. Count data is ubiquitous in statistics, frequently appearing as the aggregation of surveys, population tracking and epidemiological notifications, and an efficient data augmentation method known as Polya-Gamma expansion is available for binomial likelihoods. In the present work, we propose a scalable methods for spatial interpolation and regression of multivariate count data combining the Polya-Gamma expansion and covariance tapering, with applications to educational system survey data. This work is mainly based on Furrer, Genton and Nychka (2006), Polson, Scott and Windle (2013) and Wang et al (2023).

Funding: This work was supported by CAPES process number 88887.513578/2020-00.

References

1. Nicholas G. Polson and James G. Scott and Jesse Windle : *Bayesian Inference for Logistic Models Using Pólya–Gamma Latent Variables*, Journal of the American Statistical Association, 2013.

2. Reinhard Furrer and Marc G. Genton and Douglas Nychka: *Covariance Tapering for Interpolation of Large Spatial Datasets*, Journal of the American Statistical Association, 2006.

3. Yuan Wang and Guilherme Ludwig and Tingjin Chu and Haonan Wang: *Efficient MCMC Sampling and Variable Selection for Spatial Count Process with an Application to Rio de Janeiro Gun Violence Data*, To appear, 2023.

Multilayer networks applied to Neuroscience

Tayná Ferreira Santana

Federal University of São Carlos

In neuroscience, networks are applied to describe interactions between brain regions. When these interactions describe intracerebral and intercerebral connections for different individuals is not appropriate to represent this data using a single network. In this case, it is appropriate to model the data using multilayer networks in order to describe intralayer and interlayer connections. In this work, we apply multilayer networks to analyze data obtained from functional near-infrared spectroscopy (fNIRS), collected from an experiment aimed at teaching and learning between teacher and student.

Acknowlegments: I thank my supervisor Andressa Cerqueira and the São Paulo Research Foundation for their assistance, support and incentive in this research.

Funding: This work was supported by São Paulo Research Foundation (FAPESP), grant #2022/12733-1. The opinions, hypotheses and conclusions or recommendations expressed in this material are the responsibility of the author(s) and do not necessarily reflect the views of FAPESP.

A stationary and non-Gaussian state-space family with an approximated marginal likelihood: a new filtering inference

Thiago Rezende

Universidade Federal de Minas Gerais, Brazil

The non-Gaussian state-space (NGSS) class of [1] provides an exact marginal likelihood and smoothing procedure, dealing with high-dimensional latent parameters. However, the non-stationary evolution equation is quite restrictive in some applications. Thus, in this paper, we have extended this class to a new one, called the stationary and non-Gaussian state-space family with an approximated marginal likelihood (NGSSAML), whose latent states of the NGSSAML are obtained using an easy and fast filtering procedure. This procedure provides the marginal likelihood function with an analytical approximation for the state distribution. This approximation avoids the marginal likelihood obtained via Monte Carlo integration, reducing the computational cost. Besides, the maximum likelihood estimator (MLE) is used to estimate static parameters, and we showed that it is strongly consistent. We perform a simulation study to evaluate the estimator's properties, and our results show that the proposed model can be reasonably estimated. Furthermore, we provide a case study of the currency exchange data to illustrate the proposed approach and demonstrate its advantages against other existing models, such as low computational cost/time.

Keywords: NGSSM, currency and volatility data, count data, classical inference, MLE, consistency, asymptotic property, low computational time.

Acknowlegments: I thanks Helio Eustaquio dos Santos (in memoriam) and Alzira de Rezende dos Santos for their endless discussions.

Funding: This work was supported by from Universidade Federal de Minas Gerais-Brazil, and the FAPEMIG Foundation, APQ-00766-17.

References

1. Gamerman, Dani and Rezende dos Santos, Thiago and da Conceição Franco, Glaura: *A non-Gaussian family of state-space models with exact marginal likelihood*, Journal of Time Series Analysis, 34, 6, 625-645 (2013).

The Bell-Touchard counting process

Thomás Freud

Instituto de Matemática e Estatística da Universidade de São Paulo

The Poisson process is one of the simplest stochastic processes defined in continuous time, having interesting mathematical properties, leading, in many situations, to applications mathematically treatable. One of the limitations of the Poisson process is the rare events hypothesis; which is the hypothesis of unitary jumps within an infinitesimal window of time. Although that restriction may be avoided by the compound Poisson process, in most situations, we don't have a closed expression for the probability distribution of the increments of such processes, leaving us options such as working with probability generating functions, numerical analysis and simulations. It is with this motivation in mind, inspired by the recent developments of discrete distributions, that we propose a new counting process based on the Bell-Touchard probability distribution, naming it the Bell-Touchard process[**?**]. We verify that the process is a compound Poisson process, a multiple Poisson process and that it is closed for convolution plus decomposition operations. Besides, we show that the Bell-Touchard process arises naturally from the composition of two Poisson processes. Moreover, we propose two generalizations; namely, the compound Bell-Touchard process and the non-homogeneous Bell-Touchard process, showing that the last one arises from the composition of a non-homogeneous Poisson process along with a homogeneous Poisson process. We emphasize that since previous works have been shown that the Bell-Touchard probability distribution can be used quite effectively for modelling count data, the Bell-Touchard process and its generalizations may contribute to the formulation of mathematical treatable models where the rare events hypothesis is not suitable.

Acknowlegments: I thank Professor Pablo Rodriguez for his contribution as co-author to this work and to the Federal University of Pernambuco.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001

References

1. Freud, Thomas, and Pablo M. Rodriguez: *The Bell–Touchard counting process*, Applied Mathematics and Computation 444 (2023): 127741.

Estimating the number of hidden nodes in neural networks layers with BIC

Tiago Pereira Marques[1]
Florencia Graciela Leonardi[1]
Daniela Rodriguez[2]
Mariela Sued[2]
Liliana Forzani[3]
Universidade de São Paulo[1]
Universidad de Buenos Aires[2]
Universidad Nacional del Litoral[3]

BIC estimators with a regularization parameter to control penalty on model complexity are widely used on model selection, for example, to obtain model selection consistent estimators for the number of change points on segmented regression [1]. Similarly, we propose a BIC estimator for the number of nodes on a single hidden layer neural network, controlling the penalty on the number of nodes as a simpler alternative to grouped lasso, proven to be model selection consistent for the scenario [2]. In the poster, we will present the initial simulation results used to understand the estimator behavior.

Acknowlegments: I thank CAPES for the financial support, and the co-authors Florencia Graciela Leonardi, Daniela Rodriguez, Liliana Forzani, and Mariela Sued.

Funding: This study was financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

References

1. Kim, Jeankyung and Kim, Hyune-Ju: *Consistent model selection in segmented line regression*, Journal of statistical planning and inference, 170, 106–116 (2016).

2. Ho, Lam Si Tung and Dinh, Vu: *Searching for minimal optimal neural networks*, Statistics & Probability Letters, 183, 109353 (2022).

Application of Strong Stationary Times for Rumour Spreading in a Markovian Evolving Graph

Vicenzo Bonasorte Reis Pereira

UFSCar- Federal University of São Carlos

We study the following model for information spreading on dynamic random graphs, introduced by Clementi *et al.* (2016). The process starts with an arbitrary set of edges and a single informed node. Every edge has a Markov Chain attached to it. If an edge is vacant at time t, it will be present at time $t+1$ with probability p. If an edge exists at time t, it will be absent at time $t+1$ with probability q. At each time step a new graph is generated with this dynamic and every informed node sends the information to one node chosen uniformly between its neighbours. Using strong stationary times, we prove that, for $p = O(\frac{1}{n})$ and $q = 1$, every node is informed in $O(\log n)$ steps.

Funding: This work was supported by the São Paulo Research Foundation – FAPESP under grant 2022/08843-6

References

[1] Clementi, A., Crescenzi, P., Doerr, C., Fraigniaud, P., Pasquale, F., Silvestri, R. : *Rumor spreading in random evolving graphs*, Random Structures & Algorithms, v. 48, n. 2, p. 290-312 (2016).

[2] Levin, David A.; PERES, Yuval: *Markov chains and mixing times*, American Mathematical Soc. (2017).

Detecting renewal states in chains of variable length via intrinsic Bayes factors

Victor Freguglia

UNICAMP

Markov chains with variable length are useful parsimonious stochastic models able to generate most stationary sequence of discrete symbols. The idea is to identify the suffixes of the past, called contexts, that are relevant to predict the future symbol. Sometimes a single state is a context, and looking at the past and finding this specific state makes the further past irrelevant. States with such property are called renewal states and they can be used to split the chain into independent and identically distributed blocks. In order to identify renewal states for chains with variable length, we propose the use of Intrinsic Bayes Factor to evaluate the hypothesis that some particular state is a renewal state. In this case, the difficulty lies in integrating the marginal posterior distribution for the random context trees for general prior distribution on the space of context trees, with Dirichlet prior for the transition probabilities, and Monte Carlo methods are applied. To show the strength of our method, we analyzed artificial datasets generated from different models and one example coming from the field of Linguistics.

Acknowlegments: We thank Helio Migon and Alexandra Schmidt for fruitful discussions.

Funding: This work was funded by Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP Grants 2017/25469-2 and 2017/10555-0, CNPq Grant 304148/2020-2 and by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

[1] Freguglia, Victor and Garcia, Nancy L.: *Detecting renewal states in chains of variable length via intrinsic Bayes factors*, Statistics and Computing, 33, 1, 1-17 (2023).

Author Index