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Algebraic Curves, Computer Algebra and Integrable Systems

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Algebraic curves have significant applications in the study of the Kadomtsev-Petviashvili hierarchy, which is a universal integrable system that describes shallow water waves. The finite-genus quasi-periodic solutions of this system are expressed in terms of the Riemann theta function. These solutions, in turn, characterize the curves in the moduli space of abelian varieties, thus providing a solution to the Schottky problem. The Riemann theta function degenerates as the curve becomes more singular, leading to soliton and rational solutions. To better understand this bilateral connection, we explore various perspectives in algebraic geometry, including transcendental and combinatorial approaches, while also utilizing mathematical software. Our study yields new results and insights, along with future directions for research in this field.

A Bayesian Joint Model for Analysis of the Frequency and Duration of Physical Activity from a Lifestyle Intervention Trial

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Motivated by a lifestyle intervention trial on physical activity (PA) where behavioral scientists sought to better understand how participants change their PA activity in interventions, we are interested in developing a novel statistical model for analysis of frequency and duration of daily PA episodes measured from participants over long periods of time. Since joint modeling approaches enable us to understand the multivariate relationship between multiple outcomes and how they change over time, in this study, we propose a novel joint modeling framework for modeling PA frequencies and their duration over time. Our joint model is comprised of two submodels: a Poisson hurdle regression model with normally distributed random effects for the frequency of PA episodes per day and a location-scale Gamma regression model to characterize the duration of the PA episodes and their variance. The proposed model allows us to estimate how daily PA episode frequency and their duration vary together over the course of an intervention and is specifically designed to capture the unique distributional features of PA episodes: frequent measurements, zero-inflated PA frequencies, and skewed PA durations. We use Bayesian inference to estimate the unknown parameters of the proposed model. Lastly, we illustrate the usefulness of the proposed model through the analysis of the motivating PA intervention study data.

Higher-order Fourier analysis

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Higher-order Fourier analysis emerged from Gowers' groundbreaking work on Szemeredi's theorem. Since then the subject has developed into a multidisciplinary field including areas such as ergodic theory and discrete mathematics, with applications in areas such as analytic number theory and theoretical computer science. The key concept in the subject is the Gowers norm. Understanding qualitative and quantitative aspects of the inverse theory for the Gowers norm is of major theoretical and practical interest. An approach to the qualitative inverse theory is through ergodic theory, where it is intimately connected with the structure theory for the Host-Kra-Ziegler factors of measure-preserving systems for abelian group actions. In this talk, I will start with an introduction to the Gowers norm and then introduce and discuss the ergodic theoretical approach to its inverse theory. If time permits, I will include my contributions to resolve certain special cases of the ergodic inverse problem, which is based on joint work with Or Shalom and Terence Tao.

Random Algebraic Geometry and Random Amoebas

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Random algebraic geometry studies variable properties of typical algebraic varieties as opposed to invariant properties or extremal properties. For instance, a complex algebraic projective plane curve is always topologically connected, which is an invariant property; a real algebraic projective plane curve of degree d has, by a classical theorem of Harnack, at most $g+1 = (d-1)(d-2)/2+1$ connected components where g denotes genus, which is an extremal property; whereas a random real algebraic projective degree d plane curve in a suitable precise sense (to be explained in the talk) has an expected number of connected components of order d. In this talk, I will first present the setup and some of the main known results of the field of random algebraic geometry. I will then proceed to discuss some of our results on the expected properties of amoebas of random complex plane curves, based on a joint work with Turgay Bayraktar, and another joint work with Jean-Yves Welschinger.

Learning in Mean-Field Games

Naci Saldı
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In this talk, we consider learning approximate Nash equilibria for discrete-time mean-field games with nonlinear stochastic state dynamics subject to both average and discounted costs. To this end, we introduce a mean-field equilibrium (MFE) operator, whose fixed point is a mean-field equilibrium (i.e. equilibrium in the infinite population limit). We first prove that this operator is a contraction, and propose a learning algorithm to compute an approximate mean-field equilibrium by approximating the MFE operator with a random one. Moreover, using the contraction property of the MFE operator, we establish the error analysis of the proposed learning algorithm. We then show that the learned mean-field equilibrium constitutes an approximate Nash equilibrium for finite-agent games.
