

Abstracts

Wednesday, September 6, 2023

9:30 am – 10:30 am — Irem Portakal:

Game theory of undirected graphical models

Game theory is an area that has historically benefited greatly from outside ideas. In 1950, Nash published a very influential two-page paper proving the existence of Nash equilibria for any finite game. The proof uses an elegant application of the Kakutani fixed-point theorem from the field of topology. This opened a new horizon not only in game theory, but also in areas such as economics, computer science, evolutionary biology, and social sciences.

In this talk, we model different notions of equilibria in terms of undirected graphical models. The vertices of the underlying graph of the graphical model represent the players of the game and the dependencies of the choices of the players are depicted with an edge in the graph. This approach brings game theory in contact with the field of algebraic statistics for the first time, which offers a strong foundation for utilizing algebro-geometric tools to solve interesting problems in game theory. This is joint work with Javier Sendra-Arranz and Bernd Sturmfels.

11:00 am – 12:00 am — Mateusz Michałek:

Gröbner bases for statistical models and resultants

We will report on two recent results, that seem not related at first sight but turned out to be solvable using similar methods. On one side we provide generators of the ideal of the cyclic graphical Gaussian model confirming a conjecture by Sturmfels and Uhler. On the other side we describe the resultant ideal of n univariate polynomials of degree d . The results were obtained in joint works with Conner, Han, Shindler and Szendroi.

2:00 pm – 3:00 pm — Guido Montúfar:

Mildly Overparameterized ReLU Networks Have a Favorable Loss Landscape

We study the loss landscape of two-layer mildly overparameterized ReLU neural networks on a generic finite input dataset for the squared error loss. Our approach involves bounding the dimension of the sets of local and global minima using the rank of the Jacobian of the parameterization map. Using results on random binary matrices, we show most activation patterns correspond to parameter regions with no bad differentiable local minima. Furthermore, for one-dimensional input data, we show most activation regions realizable by the network contain a high dimensional set of global minima and no bad local minima. We experimentally confirm these results by finding a phase transition from most regions having full rank to many regions having deficient rank depending on the amount of overparameterization. This is work with Kedar Karhadkar, Michael Murray, Hanna Tseran.

Thursday, September 7, 2023

11:00 am – 12:00 am — Delaram Kahrobaei:

How Artificial Intelligence and Quantum Computing is Threatening Our Digital Future

In the dynamic realm of technological progress, the convergence of artificial intelligence (AI), quantum computing, and cybersecurity introduces unprecedented challenges and threats to societal stability. The emerging field of Post-Quantum Cryptography (PQC) remains in its early stages despite extensive research and development efforts. The National Institute of Standards and Technology (NIST) plays a pivotal role in shaping the future of PQC through its standardization process. However, recent breakthroughs in adversarial AI algorithms have exposed vulnerabilities in NIST-recommended encryption candidates, raising concerns regarding the security and reliability of PQC. This abstract highlights the urgent need for continued cryptanalysis and diversification of potential post-quantum hard problems to address the evolving landscape of AI and its potential impact on cybersecurity.

The accelerated transition to post-quantum computing poses significant risks to our current digital infrastructure, with critical sectors such as banking, finance, transportation, and essential services becoming vulnerable to quantum-enabled adversaries. Disruptions in these systems could lead to widespread chaos, financial losses, and risks to human life, emphasizing the criticality of securing our post-quantum future. Collaboration between governments, research institutions, and industry leaders is essential to conduct comprehensive research, rigorous cryptanalysis, and develop robust cryptographic systems. Moreover, a proactive pause in AI and quantum computing advancements is crucial to understand the implications, evaluate risks, and establish ethical standards and safety precautions, ensuring a secure and sustainable transition to the post-quantum era.

Symmetry is present in all forms in the natural and biological structures as well as man-made environments. Computational symmetry applies group-theory and algebra to create algorithms that model and analyse symmetry in real data set. The use of symmetry groups in optimising the formulation of signal processing and machine learning algorithms can greatly enhance the impact of these algorithms in many fields of science and engineering where highly complex symmetries exist. At the same time, Machine Learning techniques could help with solving long standing algebraic problems. Solving these hard algebraic problems could benefit the cryptanalysis of PQC proposed system.

In this talk, I will present the interactions between algebra and AI in various forms.

2:00 pm – 3:00 pm — Venkat Chandrasekaran:

Free Descriptions of Convex Sets

Convex sets arising in a variety of applications are well-defined for every relevant dimension. Examples include the simplex and the spectraplex that correspond, respectively, to probability distributions and to quantum states; combinatorial polytopes and their associated relaxations such as the cut polytope and the elliptope in integer programming; and unit balls of commonly-employed regularizers such as the Schatten norms in inverse problems. Moreover, these sets are often specified using conic descriptions that can be obviously instantiated in any dimension. We develop a systematic framework to study such free descriptions of convex sets. We show that free descriptions arise from a recently-identified phenomenon in algebraic topology called representation stability, which relates invariants across dimensions in a sequence of group representations. Our framework yields a procedure to obtain parametric families of freely-described convex sets whose structure is adapted to a given application; illustrations are provided via examples that arise in the literature as well as new families that are derived using our procedure. We demonstrate the utility of our framework in two contexts. First, we develop an algorithm for a free analog of the convex regression problem, where a convex function is fit to input-output

training data; in our setting, the inputs may be of different dimensions and we seek a convex function that is well-defined for inputs of any dimension (including those that are not in the training set). Second, we prove that many sequences of symmetric conic programs can be solved in constant time, which unifies and strengthens several disparate results in the literature. Our work extensively uses ideas and results from representation stability, and it can be seen as a new point of contact between representation stability and convex geometry via conic descriptions. (Joint work with Eitan Levin)

Friday, September 8, 2023

9:30 am – 10:30 am — Marta Casanellas:

Simple equations for phylogenetic algebraic varieties

Phylogenetics studies the evolutionary relationships among species using their molecular sequences. These relationships are represented on a phylogenetic tree or network. Modeling nucleotide or amino acid substitution along a phylogenetic tree is one of the most common approaches in phylogenetic reconstruction. One can use a general Markov model or one of its submodels given by certain substitution symmetries. If these symmetries are governed by the action of a permutation group G on the rows and columns of a transition matrix, we speak of G -equivariant models. A Markov process on a phylogenetic tree or network parametrizes a dense subset of an algebraic variety, the so-called phylogenetic variety.

During the last decade algebraic geometry has been used in phylogenetics for phylogenetic reconstruction and to establish the identifiability of parameters of complex evolutionary models (and thus guarantee model consistency). Since G -equivariant models have fewer parameters than a general Markov model, their phylogenetic varieties are defined by more equations and these are usually hard to find. We will see that we can easily derive equations for G -equivariant models from the equations of a phylogenetic variety evolving under a general Markov model. As a consequence, we will discuss the identifiability of networks evolving under G -equivariant models.

11:00 am – 12:00 am — Frank Röttger:

Conditional independence and graphical models in multivariate extremes

The recent introduction of conditional independence for multivariate extremes from threshold exceedances has inspired a new line of research in graphical extremes. In this talk we summarize recent developments and try to highlight connections with related fields. In particular we discuss directed and undirected graphical models for multivariate extremes from threshold exceedances, as well as approaches for structure and parameter learning. For the parametric family of Hüsler–Reiss distributions, extremal conditional independence can be described parametrically. This enables a parametric encoding of extremal graphical models and allows for a notion of colored graphical models in extremes. We further discuss statistical methodology for Hüsler–Reiss graphical models, which we demonstrate on a real data example.