✦2024-2025 School Year✦

MAT 180 - Special Topics

Combinatorial Representation Theory

FALL

- Instructor: Anne Schilling
- We will explore the combinatorics related to the representation theory of the symmetric group. This will involve Young tableaux and combinatorial algorithms associated to them such as the Robinson-Schensted-Knuth algorithm, jeu de taquin, and cyclage. We will study the Littlewood-Richardson rule using crystal bases, which are combinatorial skeletons of representations of the general linear group. In this course we will also explore these structures using computational tools in SageMath.

Combinatorics and Geometry via Linear Algebra

WINTER

- Instructor: Naoki Saito
- This course explores how linear algebra concepts are used in combinatorics and geometry, which are not often covered by our regular courses (e.g., MAT 22A, 145, 146, 148, 167). I plan to use a fantastic book by Jiri Matousek "Thirty-three Miniatures," Vol. 53, Student Mathematical Library, AMS, 2010.
- Topics to be covered include: distance geometry, Hamming codes, the matrix-tree theorem, etc. These will motivate many of our students who learned abstract concepts and techniques yet are left wandering what to do with them. I think it is quite important for our students to know some of these concepts and ideas. I also plan to form groups (consisting of two or three students depending on the enrollment size) and ask each group to make their presentation toward the end of this class.

Fairness and Privacy in Machine Learning

- Instructor: Thomas Strohmer
- Prerequisite: Linear algebra and a basic background in probability as well as basic experience in programming will be required. Some basic knowledge in optimization and machine learning is helpful.
- As machine learning increasingly pervades more and more aspects of our life, hitherto often ignored questions regarding social responsibility, transparency, and trustworthiness of machine learning and AI emerge as mainstream topics that pose deep and challenging mathematical problems. How do we take fairness and transparency into account while developing machine-learned models and systems? How do we protect the privacy of users when building large-scale, AI-based systems? How can we develop a rigorous understanding of the vulnerabilities inherent to machine learning? Due to their real-world implications, these topics are now at the forefront of ML and AI research. This course will introduce and analyze the mathematical concepts behind fairness and privacy of machine learning. Benefits and shortcomings of existing mathematical tools, metrics, and methods will be investigated and open problems will be discussed.

SPRING