Stanford Math Directed Reading Program Colloquium
Winter 2021

Friday 4/2, 7:15pm–8:30pm
Zoom

Euler Characteristic Through Homology

Noam Ringach
Mentor: Nikhil Pandit

In high school, we were taught that for any convex polyhedron, the number of vertices minus the number of edges plus the number of faces always equals two. Naturally, we want to know how this notion, termed the Euler characteristic, extends to shapes in higher dimensions and how similar two shapes need to be so that we can guarantee that they have identical Euler characteristics. In this talk, we will explore both of these questions using the powerful tool of simplicial homology. Finally, we circle back and prove Euler's formula using our newfound tool.

The Mathematics of Gerrymandering

Alessanda Maranca
Mentor: Pranav Nuti

Gerrymandering, the practice of drawing voting districts to give one political party or a social group an unfair edge in elections, is a reality of many countries in the contemporary world. In this talk, I will discuss some socio-mathematical concepts used to spot gerrymandering, including proportional representation, partisan symmetry, and the efficiency gap. After discussing their benefits and faults, I will talk about what the modern discussion in the area looks like, focussing on ensemble sampling and Markov Chain Monte Carlo models.

Countable Markov Chains: Drunkards and Drunk Birds.

Owen Shen
Mentor: Jared Marx-Kuo

The return probability for a symmetric simple random walk depends on the dimensions: a two dimensional drunkard will eventually return home with probability 1 while a drunk bird will have a positive chance to be lost forever.

Bounds on the Clique vs Independent set problem

Yastika Guru
Mentor: Erik Waingarten

We will first introduce the basic two-party communication model with deterministic protocols, and discuss a combinatorial approach to finding lower bounds on deterministic communication complexity. We'll then zoom in on the Clique vs. Independent Set problem, prove an $O(\log^2 n)$ upper bound and briefly survey the open problem of proving a lower bound better than $\omega(\log n)$.

Topological Data Analysis

Jacob Bedia
Mentor: Shintaro Fushida-Hardy

Topological data analysis (TDA) applies concepts from algebraic topology to understand a space's structure through its holes. Fundamental TDA techniques will be summarized, including Betti numbers, simplicial complexes, filtrations, and persistent homology. Finally, an application to viral genetic data (Chan, Carlsson, and Radaban PNAS 2013) will be detailed.

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