11th Annual Davis Math Conference
Schedule and Abstracts

Organizing Committee: Brittany Leathers and Black Jiang

Thursday, January 28, 2021

Schedule

Mathematical Biology	9:30 AM - 9:55 AM	Rishidev Chaudhuri
Mathematical Biology	10:00 AM - 10:25 AM	Leighton Izu
Coffee Break		
Analysis	11:00 AM - 11:25 AM	Kevin O'Neill
Topology	11:30 AM - 11:55 AM	Roger Casals
Lunch Break		
Atmospheric Dynamics	1:30 PM- 1:55 PM	Terry Nathan
Reinforcement Learning	2:00 PM - 2:25 PM	Xin Liu
Coffee Break		
Combinatorics	3:00 PM - 3:25 PM	Anastasia Chavez
Coffee Break		
Algebraic Geometry and Combinatorics	4:00 PM-4:25 PM	Eugene Gorsky

Titles and Abstracts

1 Rishidev Chaudhuri - Mathematical Biology

Title: Why are brains so noisy?

Abstract: Noise is ubiquitous in neural computation but it is unclear whether this "noise" plays an important functional role, is averaged away, or reflects the encoding of unknown variables. In this talk I will propose that noisy fluctuations might allow the brain to identify and remove redundant connections in a neural network, using a simple noise-driven learning rule. Drawing on tools from noisy dynamical systems and the theory of graph sparsification, I will prove that this rule has excellent performance. For a subset of linear and rectified-linear networks, this rule provably preserves the spectrum of the original matrix and hence preserves network dynamics even when the fraction of removed synapses asymptotically approaches 1. This is joint work with Eli Moore.

2 Leighton Izu - Mathematical Biology

Title: Understanding How Complex Systems Work

Abstract: Understanding biological systems is challenging because they comprise myriad parts and these parts need to be coordinated to achieve some functional output or to keep the system in a particular state. The central tenet of the omics revolution (genomics, proteomics, phenomics, etc.) is that knowledge of the interactions of component parts is fundamental to understanding biological systems. The *Functional Connectome* we developed determines the pattern of coordination between components in datasets. The Functional Connectome is based on the singular value decomposition (SVD) of the data matrix but goes further by exploiting the natural partitioning that occur in many datasets. I'll show how the Functional Connectome is used to analyze wines and patients with heart failure.

3 Kevin O'Neill - Analysis

Title: Can you Find a C^m Function...?

Abstract: Given a compact set $E \subset \mathbb{R}^n$ and a function $f : E \to \mathbb{R}$, how can we tell if there exists $F \in C^m(\mathbb{R}^n)$ such that $F(x) = f(x)$ for all $x \in E$? This problem was posed by Whitney nearly a century ago, but recent research has solved this and related problems. This talk will focus on research in this area done at UC Davis, as well as connections with other fields, such as algebra, algebraic geometry, and data science.

4 Roger Casals - Topology

Title: An Invitation to Legendrian Knots

Abstract: In this short talk, I will discuss Legendrian knots and their applications. First, the necessary

definitions and historical motivation will be provided. Then I will present some of the recent developments in this area of topology, and talk about a selection of current research problems.

5 Terry Nathan- Atmospheric Dynamics

Title: Conditions for the Instability of Atmosphere Jets

Abstract: Hydrodynamic instability has a rich history, dating back to the 19th century when Lord Rayleigh (1880) derived necessary conditions for the instability of homogeneous, plane parallel flow. Rayleigh's inflection point theorem, as it's now known, states that if the (jet) flow is devoid of an inflection point, it is stable. Violation of this condition is necessary for the development of waves. Kuo (1949) extended Rayleigh's theorem to include the rotational effects of Earth, while Charney and Stern (1961) also included the effects of stratification. Charney and Stern, for example, provide the necessary conditions for the instability of the atmospheric jet stream, whose instability manifests in waves that we associate with the high and low pressure systems that characterize the weather at middle latitudes. All of these classic studies have one thing in common: they were carried out for conservative flow.

Among the most important non-conservative processes operating in Earth's atmosphere is the heating produced by trace shortwave radiative absorbers, which include stratospheric ozone and mineral dust. In this brief talk, I will introduce my current study, in which I derive necessary and sufficient conditions for the radiative-dynamical instability of large-scale atmospheric waves induced by trace shortwave radiative absorbers. The analysis pivots on a pseudomomentum conservation equation that is obtained by combining equations for quasigeostrophic potential vorticity, thermodynamic energy, and trace absorber mixing ratio. Under the assumptions that the diabatic heating rate due to the absorber is small and the zonal-mean basic state is hydrodynamically neutral, a perturbation analysis of the pseudomomentum equation yields the conditions for instability. The conditions, which only require knowledge of the zonally-averaged background distributions of wind and absorber, expose the physical processes involved in the destabilization.

The conditions for instability have broad application to synoptic-scale weather systems, ranging from biomass burning of aerosols, to stratospheric ozone, to dust storms on both Earth and Mars. The simplicity of the instability conditions underscores their utility as a tool that is both interpretive and predictive.

6 Xin Liu - Reinforcement Learning

Title: Reinforcement Learning: Algorithm Development and Applications

Abstract: [TBA]

7 Anastasia Chavez - Combinatorics

Title: Matroids, Poistroids, and Combinatorial Characterizations

Abstract: Matroids are a fundamental combinatorial object that has connections to many areas of mathematics: algebraic geometry, cluster algebra, coding theory, polytopes, physics ... just to name a few. We will explore definitions, examples, and a few results so that you too can begin spotting the matroids hiding among us.

8 Eugene Gorsky - Algebraic Geometry & Combinatorics

Title: Braid Varieties

Abstract: I will define braid varieties, a class of affine algebraic varieties associated to positive braids, and describe some of their properties. This is a joint work with Roger Casals, Mikhail Gorsky and Jose Simental Rodriguez.