Graduate Student Research Showcase

University of Tennessee, Knoxville - Department of Mathematics
November 21, 2019
http://siam.math.utk.edu

Abstract

The Graduate Student Research Showcase gives current graduate students the chance to present their research to their peers. Presenters are free to give a big picture view of their work, a selective offering, or anything in between. Presentations will cover a variety of disciplines and topics therewithin as well as the interests of numerous faculty advisers. Student attendees should expect to leave the showcase with a better understanding of what work is being done by fellow graduate students and what types of problems advisors are interested in studying.

Session One - Ayres 123, 5-6pm

- **Speaker:** *Cassie Micucci*

  Title: Determining the Structure of the Actin Cytoskeleton via Bayesian Topological Learning

- **Speaker:** *Adam Spannaus*

  Title: Atom Sequencing for Disordered Materials

- **Speaker:** *Shane Sawyer*

  Title: Connections Between Architecture and Neural Network Expressiveness

Session Two - Ayres 124, 5-6pm

- **Speaker**: *Tyler Poppenwiner*

  Title: Modelling Root Stage Distributions: Effects on Plant Growth, Root Turnover, and Resource Cycling

- **Speaker:** *Stephen McCoy*

  Title: Qualitative Investigation of Cytolytic and Noncytolytic Immune Response in a HBV Model

- **Speaker:** *Margaret Grogan*

  Title: Malaria and an Adventure through ODEs, Integral Equations, and Data

Session Three - Ayres 123, 6-7pm

- **Speaker:** *Mitchell Sutton*

  Title: A New Theory of Fractional Differential Calculus, Fractional Sobolev Spaces, and FPDEs

- **Speaker:** *Jeahyun Park*

  Title: Computational and Applied Mathematics Research Under the Advisement of Dr. Salgado and Dr. Wise

- **Speaker:** *Michael Wise*

  Title: Multilevel Additive Schwarz Methods for Discontinuous Galerkin Approximations of Elliptic Equations

Session Four - Ayres 124, 6-7pm

- **Speaker:** *Maggie Wieczorek*

  Title: Modular Forms, q-Series, and Partitions

- **Speaker:** *Gabriel John Dusing*

  Title: On Discerning the Relative Realizability of Tropical Curves

- **Speaker:** *Jack Ryan*

  Title: Loewner Hulls

Food will be served for presenters and attendees at 7pm in Ayres 405.

Please RSVP at http://siam.math.utk.edu.

Graduate Student Research Showcase

Session One - Ayres 123, 5-6pm

- **Speaker:** *Cassie Micucci*

  Title: Determining the Structure of the Actin Cytoskeleton via Bayesian Topological Learning

  Abstract: This presentation explores the computation of posterior distributions from a new Bayesian framework for persistence diagrams. Persistent homology is a method that explores topological and geometric properties of point clouds and summarizes them as persistence diagrams. We explain our proposed Bayesian framework which adopts a point process characterization of persistence diagrams. This framework provides the flexibility to estimate the posterior cardinality and intensity of persistence diagrams simultaneously. We present a closed form of the posterior intensity and cardinality using Gaussian mixtures. Based on this form, we implement an effective Bayes factor classification algorithm on filament network data of plant cells.

- **Speaker:** *Adam Spannaus*

  Title: Atom Sequencing for Disordered Materials

  Abstract: Materials science researchers are able to investigate the local structure of a new class of metallic alloys through a process called atom probe tomography (APT). This process yields the elemental type and spatial coordinates of each successfully detected atom, but does not yield small-scale elemental ordering or lattice structure. Moreover, each successfully detected point has its coordinates perturbed by some experimental noise. I will present my work incorporating topological features via persistence diagrams to classify the lattice structure of point cloud data arising from this materials science data. Furthermore, I will present the statistical theory and algorithms that I developed to give materials scientists a snapshot of the atomic-level structure present in these novel alloys. We are able to extract fundamental information about the material through a combination of Bayesian inference, topology, machine learning, and variational inference.

- **Speaker:** *Shane Sawyer*

  Title: Connections Between Architecture and Neural Network Expressiveness

  Abstract: I am working under the supervision of Dr. Clayton Webster, the director of the Computational and Applied Mathematics group at Oak Ridge National Laboratory and Professor of Mathematics in our department. Much of the focus in Dr. Webster's research group is in the mathematical underpinnings of neural networks.

  Neural networks are a particular method from the broader class of machine learning algorithms. Examples of the impact of neural networks are ubiquitous: fraud detection, optical character recognition, detecting medical conditions, and classifying cat images. The benefit of neural networks is indeed proven by their success in so many diverse fields. But, why they are so successful is an open research topic.

  In this short presentation, I will review some of the key features of neural networks and provide an overview of foundational and current research papers in the field. I will discuss the connections between neural networks and applied mathematics and which directions my research may follow.

Session Two - Ayres 124, 5-6pm

- **Speaker**: *Tyler Poppenwiner*

  Title: Modelling Root Stage Distributions: Effects on Plant Growth, Root Turnover, and Resource Cycling

  Abstract: Roots are important mediators of plant-soil feedbacks, but models often simplify them to a single element or are only implicitly incorporated. Roots are not homogenous and root stages have varying cost/benefit ratios. The effects of alternative root stage distributions on plant growth and the factors influencing them are understudied. The experimental intractability of direct examination lends itself to a model framework. We apply a spatial stage-based matrix population model using varying resource acquisition, survivorship, transportation capacity, and maintenance costs for different root stages to analyze stage distribution across a plant?s life. A simulated perennial plant expands into a 2-dimensional soil environment. We include growth and ageing feedbacks to integrate the acquisition of resources by roots and carbon from photosynthesis. A parameter space searchinvolving allmodelparameters affecting growth, transport, uptake and allocation assumptions,will be used to examine the impacts of changing root stage distribution on individual plant growth. It will also be used to determine conditions under which stage distribution dynamics tend towards a steady state, cycle, or fluctuate in a non-periodic manner.

- **Speaker:** *Stephen McCoy*

  Title: Qualitative Investigation of Cytolytic and Noncytolytic Immune Response in a HBV Model

  Abstract: This talk presents a new mathematical model of infection by the hepatitis B virus (HBV) that includes the cytolytic and noncytolytic immune response. The model exhibits a variety of steady-state solutions depending on parameter values including ranges that determine both non-unique and unique equilibrium solutions and ranges over which there is periodic behavior. The basic reproduction ratio is computed and the disease free equilibrium and positive disease equilibrium are examined in the case of uniqueness. Parameter conditions are determined so that this equilibrium is locally stable. The importance of healthy cell count on the effects of cytolytic and noncytolic behavior is also examined.

- **Speaker:** *Margaret Grogan*

  Title: Malaria and an adventure through ODEs, Integral Equations, and Data

  Abstract: Did you know that mosquitoes are classified as the deadliest animal in the world? They cause the spread of many diseases, the worst of which is malaria. According to the WHO 2018 Malaria Report, it caused over 435,000 deaths in 2017 of which 266,000 were children under the age of 5. So how should we combat these killers? My research delves into modeling treatment within an SIR framework for vector-borne diseases. We will first look into defining a system of ODEs that account for drug-sensitive and drug-resistant strains of malaria. This model will lead us to question the structure that we predetermined for our system. Hence we develop a second model incorporating time-since-infection that will lead to a system of integral equations that can define our structure for us. Lastly, we always need to consider what type of real data is out there to help us parametrize our systems.

Session Three - Ayres 123, 6-7pm

- **Speaker:** *Mitchell Sutton*

  Title: A New Theory of Fractional Differential Calculus, Fractional Sobolev Spaces, and FPDEs

  Abstract: We present a new theory of weak fractional differential calculus and fractional Sobolev spaces. The crux of this new theory is the introduction of a weak fractional derivative concept which is a natural generalization of integer order weak derivatives, it also helps to unify multiple existing fractional derivative concepts. Based on the weak fractional derivative concept, new fractional order Sobolev spaces are introduced and many important properties, such as density theorem, extension theorem and trace theorem, of those Sobolev spaces are established. Sobolev spaces (and their inherited weak derivative concept) are one of the most important function spaces in the study of PDEs and the development of efficient numerical methods. With the newly introduced weak fractional derivative(s) and associated fractional Sobolev spaces, we consider new families of PDEs.

- **Speaker:** *Jeahyun Park*

  Title: Computational and Applied Mathematics Research under the advisement of Dr. Wise and Dr. Salgado

  Abstract: We will overview mathematics and physics very roughly from a CAM researcher's perspective. We will also look at some examples at an accessible level.

- **Speaker:** *Michael Wise*

  Title: Multilevel additive Schwarz methods for discontinuous Galerkin approximations of elliptic equations

  Abstract: We consider a class of symmetric interior-penalty discontinuous Galerkin formulation for second-order elliptic equations. To precondition the resulting linear system, we employ a multilevel additive Schwarz domain decomposition technique. We present condition number estimates for both non-overlapping and overlapping subdomains. We present the results of numerical experiments which serve to validate the theory.

Session Four - Ayres 124, 6-7pm

- **Speaker:** *Maggie Wieczorek*

  Title: Modular forms, q-series, and partitions

  Abstract: Partition theory has long been a source of research for number theorists. Various partition functions can often be connected to the theory of modular forms through their generating functions when written as q-series. In this talk, we?ll see explore definitions and facts about modular forms and partitions as well as see a few current results about partitions that use the tools and techniques of modular forms.

- **Speaker:** *Gabriel John Dusing*

  Title: On Discerning the Relative Realizability of Tropical Curves

  Abstract: Every ideal in a polynomial ring over a field can be a tropicalized to give a tropical variety. However, not all tropical varieties have a corresponding ideal. We discuss a method to decide if a tropical curve Σ (that is, a 1-dimensional tropical variety) has an ideal whose tropicalization is Σ.

- **Speaker:** *Jack Ryan*

  Title: Loewner Hulls

  Abstract: The Loewner differential equation is a tool that can be used to provide a correspondence between compact sets in the closure of the upper half-plane and continuous real-valued functions. Without going into the details of the complex analysis that provides this correspondence, we will explore some of the natural questions that arise in the study of this theory and provide a brief survey of results that give partial answers to these questions. We will then illustrate a specific example of a continuous function and explore its behavior as it pertains to the relevant questions.