Celebration of Women in Mathematics
Lightning Research Talks – March 18, 2022

Name: Marina Mancuso
Pronouns: She/they
Advisor's name: Fabio Milner
Area of research: Applied Math/Mathematical Biology
Title: Infection-age Dependence in West Nile Virus Disease Modeling
Abstract: The transmission of mosquito-borne diseases, such as malaria, dengue fever and West Nile Virus (WNV), is influenced by various time-dependent processes, including climate, land cover, and even the age of mosquito vectors. This talk will introduce a partial differential equations model that elucidates the nonlinear relationship between infection-age and disease transmission in bird hosts and mosquito vectors. We'll further discuss our plans to fit our model to historical WNV data from temperate and desert climates, and provide insight into how these different climates impact WNV transmission.

Name: Sandra Cole
Pronouns: She/her
Advisor: Stephen Wirkus
Area of research: Applied Math
Title: Modeling the Dynamics of Heroin and Illicit Opioid Use Disorder, Treatment, and Recovery
Abstract: Opioid use disorder (OUD) has become a serious leading health issue in the United States leading to addiction, disability, or death by overdose. Research has shown that OUD can lead to a chronic lifelong disorder with greater risk for relapse and accidental overdose deaths. While the prescription opioid epidemic is a relatively new phenomenon, illicit opioid use via heroin has been around for decades. Recently, additional illicit opioids such as fentanyl have become increasingly available and problematic. We propose a mathematical model that focuses on illicit OUD and includes a class for recovered users but allows for individuals to either remain in or relapse back to the illicit OUD class. Therefore, in our model, individuals may cycle in and out of three different classes: illicit OUD, treatment, and recovered. We additionally include a treatment function with saturation, as it has been shown there is limited accessibility to specialty treatment facilities. We used 2002-2019 SAMHSA and CDC data for the U.S.population, scaled to a medium-sized city, to obtain parameter estimates for the specific case of heroin. We found that the overdose death rate has been increasing linearly since around 2011, likely due to the increased presence of fentanyl in the heroin supply. Extrapolation of this overdose death rate, together with the obtained parameter estimates, predict that by 2038 no endemic equilibrium will exist and the only stable equilibrium will correspond to the absence of heroin use disorder in the population. There is a range of parameter values that will give rise to a backward bifurcation above a critical saturation of treatment availability. We show this for a range of overdose death rate values, thus illustrating the critical role played by the availability of specialty treatment facilities. Sensitivity analysis consistently shows the significant role of people entering treatment on their own accord, which suggests the importance of removing two of the most prevalent SAMHSA-determined reasons

that individuals do not enter treatment: financial constraints and the stigma of seeking treatment for heroin use disorder.

Name: Shuyi Li
Advisor: Shiwei Lan
Pronouns: She/her
Area of research: Statistics
Title: Scaling Up Bayesian Uncertainty Quantification for Inverse Problems Using Deep Neural Networks
Abstract: Due to the importance of uncertainty quantification (UQ), Bayesian approach to inverse problems has recently gained popularity in applied mathematics, physics, and engineering. However, traditional Bayesian inference methods based on Markov Chain Monte Carlo (MCMC) tend to be computationally intensive and inefficient for such high dimensional problems. To address this issue, the calibration-emulation-sampling (CES) scheme has been proposed and proven to be successful in large dimensional UQ problems. In this work, we propose a novel CES approach for Bayesian inference based on deep neural network models for the emulation phase. The resulting algorithm is computationally more efficient and more robust against variations in the training set. Further, by using an autoencoder (AE) for dimension reduction, we have been able to speed up our Bayesian inference method up to three orders of magnitude. Henceforth we called Dimension-Reduced Emulative Autoencoder Monte Carlo (DREAMC) algorithm.

Name: Abby Rocha
Advisor: Marilyn Carlson
Pronouns: She/her
Area of research: Mathematics Education
Title: An Investigation into Instructors' Mathematical Meanings for Teaching
Abstract: Prior research suggests that a teacher's mathematical meanings for an idea constitute their image of the mathematics they teach (Thompson, 2013), their pedagogical decisions, and the language they use to cultivate similar images in students' thinking (Thompson & Thompson, 1996). As such, it seems reasonable that there is a link between teachers' meanings for the ideas they teach and their instruction, including teachers' instructional goals, choice of tasks, and the questions they pose to students. However, few researchers have investigated teachers' mathematical meanings for teaching (MMT). More concerning is the results of the few studies that have. As one example, Byerley and Thompson (2017) reported that most secondary mathematics teachers they studied provided formulaic or chunky descriptions of slope in contrast to thinking of slope as a rate of change that involves a multiplicative comparison between changes in two quantities. Other researchers who have investigated teachers' MMT have reported similar findings highlighting the impoverished nature of US teachers' mathematical meanings (Musgrave & Carlson, 2017; Yoon & Thompson, 2020; Thompson & Milner, 2018). In this talk I will describe the affordances of attending to teachers' meanings opposed to their declarative knowledge. I will then motivate the need for more investigations into teachers' MMT.

Name: Miandra Ellis
Pronouns: She/her
Advisor: Rosemary Renaut
Area of research: Numerical Linear Algebra
Title: Non-Standard Quadratures in Inverse Problems
Abstract: The topic of my research is numerical linear algebra with applications to inverse problems. Inverse problems seek to form an approximation of some unknown given collected data and an approximation to a forward model. Real world forward models are high dimensional and have constraints that are often not well modeled by the existing testing models used to test new algorithms. These insufficiencies warrant a deeper look at the elementary methods that are used as the foundation for forming approximations to the forward model. This work addresses these limitations by developing new numerical methods based on quadratures which are not commonly used for inverse problems.

Name: Esther Boyle
Pronouns: She/her
Advisor: Petar Jevtic
Area of research: Statistics, Data Science, Risk Analysis
Title: Social Vulnerability and Power Loss Mitigation: A Case Study of Puerto Rico
Abstract: The island of Puerto Rico within the Caribbean Atlantic is regularly subject to severe tropical storms and hurricanes that damage the power network infrastructure. However, these power grid disturbances tend to have disproportionate effects on human livelihood in vulnerable communities. In this interdisciplinary work, we propose a simulation based framework to identify critical system components of power networks for targeted hardening in light of social vulnerability. This effort is of particular importance in island communities such as Puerto Rico, where hurricanes are frequent and resources are limited, and where the spatially diverse effects of power loss on human suffering are all the more severe. Our simulation approach incorporates topological network theory, risk analysis, engineering models, climatological data, and social vulnerability metrics produced by the CDC.

Name: Alaa Haj Ali (Postdoctoral Scholar)
Pronouns: She/her
Area of research: Partial Differential Equations
Title: On obstacle-type free boundary problems
Abstract: Free boundary problems arise naturally in physics, biology, and mathematical finance, and their mathematical models feature an a-priori unknown interface which is called *free boundary*. Some of the main objectives when studying free boundary problems are the well-posedeness of the problem, the regularity of the solution across the free boundary, and the regularity and structure of the free boundary. We will introduce our research in the area of obstacle type problems, which are particular types of free boundary problems. We will give a quick overview on the approaches we follow and the tools we adapt.

Name: Mirjeta Pasha (Postdoctoral Scholar)
Pronouns: She/her

Area of research: Computational Mathematics
Title: Seeing the Invisible: Mathematics of Imaging
Abstract: Images are ubiquitous in many fields of science and engineering, biology, medicine, and geophysics.
Three emerging challenges on obtaining relevant solutions to large-scale and data-intensive imaging inverse problems are ill-posedness of the problem, large dimensionality of the parameters, and the complexity of the model constraints.
This talk will describe the concept of an inverse problem and show snapshots from a variety of methods that are used to remedy the common difficulties. An example from computerized tomography will be used for illustration.