ADVANCING STUDENT PARTICIPATION IN RESEARCH EXPERIENCES

ASPIRE in MATH

Program & Abstracts
February 4, 2023

FGCU | COLLEGE OF ARTS & SCIENCES Mathematics

Contents

Schedule

Time	Event
8 -9 am	Registration in Seidler Lobby. Breakfast in Seidler Room 220

Time	Morning Session - Seidler 114
09:00 am	Opening Remarks *Clay Motley*, CAS Interim Dean, Florida Gulf Coast University
09:10 am	Undergraduate research: How to Get Started and What to Expect? *Mihhail Berezovski*, Embry-Riddle Aeronautical University
10:00 am	**Break and Networking**
10:15 am	What can we, as mathematicians, bring to the table? *Alberto Condori*, Florida Gulf Coast University
11:00 am	Panel Discussion - Q&A and Group Photograph

Time	Event
12:00 am- 12:45 pm	Lunch in Seidler Room 220
12:00 am- 12:45 pm	Posters are displaced in Seidler Room 220

Time	Parallel Session 1 - Seidler 220	Parallel Session 2 - Seidler 114
12:45 pm	Female Astronauts from STEM Fields *Jiangduo (Ginger) Chen*, Florida Institute of Technology	Quantifying Uncertainty in Ensemble Deep Learning *Emily Diegel*, Embry-Riddle Aeronautical University
01:05 pm	Nonlinear Schrödinger Equation in a Periodic Setting *Beckett Sanchez*, Florida International University	Bounds on Large Gaps Between Sums of Two Squares *Michael Ilyin*, Florida International University
01:25 pm	**Break**	
01:45 pm	Finite Distributive Lattice Structures *Lauren Culligan*, Florida Atlantic University	Nonlinear Schrödinger Equation with Combined Nonlinearities *Gia Azcoitia*, Florida International University
02:05 pm	Modeling Tuberculosis Granuloma with Differential Equations *Dennis Whitener*, Florida Gulf Coast University	What is the Full Price of a Plastic Spoon? An Externalities Estimation Equation *Kevin Santamaria*, Florida International University
02:25 pm	Florida Has a Prison Problem: Examining the Relationship Between Carceral Rates and Socioeconomic Factors With Statistical Analysis *Samantha Scardelletti*, Florida Gulf Coast University	
02:45 pm	**Closing Remarks**	

ASP*i*RE

Advancing Student Participation in Research Experiences (ASP*i*RE) is an annual conference held at Florida Gulf Coast University each February to educate students about what it means to do “mathematics research" and inform them of research opportunities.

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Sponsors

The conference is funded by the FGCU College of Arts and Sciences, McGinnis Educational Services, the FGCU Whitaker Center STEM Education, the FGCU Office of Undergraduate Studies, the Office of Scholarly Innovation and Student Research, Textbook Publishers and the FGCU Department of Mathematics.

Abstracts of Keynote Lectures

Undergraduate research: How to Get Started and What to Expect?

Mihhail Berezovski

Embry-Riddle Aeronautical University

Undergraduate research is a learning activity that enriches a student's undergraduate experience. Undergraduate research opportunities extend across disciplines, taking many forms and offering benefits regardless of major. In this talk, we highlight the benefits of undergraduate research. We will discuss how to get started, what to expect and how to prepare for undergraduate research. We will overview several different undergraduate research opportunities and student trainings options. We will talk about the experience of mentoring undergraduate students in multiple data-enabled research projects, based on original real-world problems provided directly by businesses and industry. We also discuss in details the NSF REU Site at Embry-Riddle Aeronautical University requirements and outcomes.

What can we, as mathematicians, bring to the table?

Alberto Condori

Florida Gulf Coast University

Mathematics is a rich, intellectually challenging, and engaging subject that helps our society with everyday decision making. It has the power to provide insight into solving some of the world's greatest challenges and can lead to substantive interdisciplinary dialogues with biologists, entomologists, computer scientists, and colleagues at the national labs. In this talk, I will discuss how some of my recent work exemplifies that mathematics can be found everywhere, its importance to our society, and how it can be seen as the subject that interconnects many other fields, e.g. software development, biology, statistics, data science, etc.

Abstracts of Talks

Bounds on Large Gaps Between Sums of Two Squares

Michael Ilyin

Florida International University

I will present some classic results from number theory about numbers that are representable as a sum of two squares. I will explain how the bounds on large gaps between sums of two squares provide information regarding the distribution of representable numbers. I will discuss the state-of-the-art estimates for the bounds and provide the number-theoretical and geometric motivation for the construction of the lower and upper bound results.

Female Astronauts from STEM Fields

Jiangduo (Ginger) Chen

Florida Institute of Technology

Females have been criticized as the wrong sex in the "right stuff"- space programs due to the science, cultural, and political factors (Weitekamp, 2001). Are science and technology harder for females than males? Why has the STEM field witnessed a gender gap? Why the number of female astronauts is no more than 10% of that of male astronauts? What exceptional challenges and experiences that female astronauts have overcome to devote themselves to a space mission program? Noreen (2012) with her regression analysis shows that women empowerment is considerably influenced by age, education of husband, father inherited assets, marital status, number of sons alive, and microfinance. Taking a deeper scrutiny to predictors of female empowerment, the target of the study is to engage young female talents to study STEM through empowerment and female astronauts' career path development.
By exploring the key factors of the gender gap in STEM education and career choices (Tandrayen-Ragoobur & Gokulsing, 2021) and the issues facing crew selection for space flight missions (Nakushian & Deaton, 2020), this research study will apply D-STEM (diversify STEM) Equity Model (Coleman, 2020) to address and answer the identified problems collectively for female astronauts in the space industry. The purpose of this study is to demystify the sociocultural, contextual, biological, and psychological factors to individual and gender differences in STEM interests and career choices with expectancy-value theory (Wang & Degol, 2013), in order to fortify females' autonomy in making their own decisions without societal, cultural, and biological barriers constraining them but with free will.

Finite Distributive Lattice Structures

Lauren Culligan

Florida Atlantic University

Lattice Theory is a relatively new area of interest in mathematics. In the 1930s, Garrett Birkoff demonstrated the importance of lattice theory which provides a unifying framework for unrelated developments in many mathematical disciplines. In this study, the diagrams of finite distributive lattice structures will be made into diagrams of n many elements so that they may be analyzed. It is predicted that there will be certain patterns that emerge from the diagrams that are constructed. Once a sequence has been determined, the goal will be to identify exactly how these lattice structures will look like and the type of elements that will make up these structures. If possible, applications in various areas of science will be identified based on these lattice structures.

Florida Has a Prison Problem: Examining the Relationship Between Carceral Rates and Socioeconomic Factors With Statistical Analysis

Samantha Scardelletti

Florida Gulf Coast University

With an incarceration rate of 795 people per 100,000 in 2021, Florida imprisons more of its residents than nearly any other democracy in the world (Prison Policy Initiative, 2021). Between 2009 and 2019, that rate peaked in Bay County, where there were 9,472 arrests per 100,000 in 2019 alone. For comparison, Collier County reported about half as many arrests that year despite a population more than twice as large (Florida Department of Law Enforcement, 2019). The present study aims to clarify which socioeconomic factors most significantly contribute to Florida's prison problem by focusing on Bay County, where the problem is the most pronounced. Known contributors to mass incarceration include racial and ethnic biases, gender, disparities in education quality, disproportionate poverty levels, inadequate access to mental health care, and job insecurity (Flores, 6). As such, to determine which factors are most impactful on Bay County's incarceration rate, we will conduct a series of least-squares and analysis of variance (ANOVA) tests with sample data collected the Florida Department of Law Enforcement. Ultimately, our goal is to understand what drives Bay County's overinflated incarceration rates to help stem the tide of mass incarceration in Florida.

What is the Full Price of a Plastic Spoon? An Externalities Estimation Equation

Kevin Santamaria

Florida International University

Plastic is an environmental problem. But it is also an economic one. The issue with plastic is that the existing market price is sending producers and consumers the incorrect incentives, i.e., an incomplete price is being transmitted throughout the plastic supply chains and consumption habits. Plastic waste is an example of a negative externality. A negative externality is defined as a cost to a third-party that was not included in the original market transaction. In the case of plastic, the original market transaction is between the consumer and producer, while the third party is the environment, animals and other people who suffer from the negative impacts of plastic waste accumulating in ecosystems. When a negative externality is present, firms over-produce the good, since it is being under-priced. This is because the market clearing price does not take into account the external damage being caused. An equation to estimate negative externalities is derived and explained. Using conservative estimates, a plastic spoon causes roughly $0.03 in externalities. We estimate that the full price of a plastic spoon with the externality included is about $0.07. Thus, the externality is equal to about 75% of the market price of a spoon. Unlike other methods in the economic literature, the externality estimation equation allows us to obtain item-specific cost and benefit information. This equation can be used by both governments and corporations wishing to compare items at their full ecological price. A future is possible where plastic is only used in durable items and biodegradable alternatives are the primary use for single-use items. However, this is only possible if the negative externalities are internalized in prices.

Modeling Tuberculosis Granuloma with Differential Equations

Dennis Whitener

Florida Gulf Coast University

Tuberculosis is a viral disease that is caused by a bacterium known as Mycobacterium tuberculosis. Once the bacterium enters the lung, it causes a cascade of immune response resulting in a well-organized structure of immune cells called granuloma, the hallmark of TB. In this presentation, we talk about how to use a set of differential equations to model this immune response. We present a quick stability analysis along with numerical simulations illustrating the impact of some parameters.

Nonlinear Schrödinger Equation in a Periodic Setting

Beckett Sanchez

Florida International University

We consider the nonlinear Schrödinger (NLS) equation

$$\begin{cases} iu_t + \Delta u + \lambda N(|u|)u = 0, \quad x \in \mathbb{T}^N,\ t \in \mathbb{R}; \\ u(0,x) = u_0(x) \end{cases}$$

on a periodic domain $\mathbb{T}^N$, where either $N(|u|) = \sum_{k=0}^{\infty} a_k |u|^{\gamma_k}$ with $a_k, \gamma_k \in \mathbb{R}$, or $N(|u|) = \log(|u|)$. We assume that our initial data $u_0(x)$ lives in the Sobolev space H^J for $J \geq \lfloor N/2 \rfloor + 3$. With this, we show that the integral equation of the above NLS equation

$$\Psi(u) = e^{it\Delta}u_0 + i\lambda \int_0^t e^{i(t-s)\Delta}\big(N(|u|)u\big)(s)\, ds \tag{4.1}$$

is a contraction mapping on the complete metric space $\mathcal{Z}_{T,R}$ (a certain subspace of H^J) and a specific condition on the coefficients $\{a_k, \gamma_k\}$. From this it follows that there exists a unique solution for some finite time $T > 0$. Considering $N(|u|)$ to be an infinite power series also yields solutions for such nonlinearities as the exponential, $e^{|u|}$, or sinusoidal, $\sin(|u|)$, potential (among various others nonlinearities). The well-posedness for such nonlinearities have been studied on a whole space, i.e., for $x \in \mathbb{R}$. The novelty of this project is to consider the periodic setting and show the well-posedness of solutions to the above equation with nonlinearities that are not possible to consider on the whole space, for example, nonlinearities with negative powers: $\frac{u}{|u|}$ and $\frac{u}{e^{|u|}}$.

Nonlinear Schrödinger Equation with Combined Nonlinearities

Gia Azcoitia

Florida International University

We consider the one-dimensional nonlinear Schrödinger equation

$$iu_t + u_{xx} + \mathcal{N}(u) = 0, \quad x, t \in \mathbb{R},$$

with the nonlinearity term that is expressed as a sum of powers, possibly infinite:

$$\mathcal{N}(u) = \sum c_n |u|^{\alpha_n} u, \quad \alpha_n > 0.$$

The combined nonlinearities appear in various physical applications such as chemical super fluidity, or the description of elementary particles such as bosons and defectons, or other subatomic structures, and in approximations of anisotropic media.

We first investigate the local well-posedness of this equation for any positive powers of α in a certain weighted class of initial data, subset of $H^1(\mathbb{R})$. Then, using the pseudo-conformal transformation, we extend the local result to the global well-posedness. Furthermore, we investigate the asymptotic behavior of global solutions, those that have initial data with a quadratic phase $e^{ib|x|^2}$ with sufficiently large positive b. In particular, we prove scattering of these solutions in $H^1(\mathbb{R})$. One of the advantages of considering an infinite sum in the nonlinearity term is being able to consider exponential nonlinearities, such as $e^{\alpha|u|^k}u$, as well as sine or cosine nonlinearities, and obtain well-posedness in those cases, the first such result for most of those nonlinearities.

To conclude, we show numerical simulations in the focusing case for various examples of combined nonlinearities, including the exponential one, and investigate a threshold behavior for the global versus finite time existing solutions, which extends our theoretical results.

Quantifying Uncertainty in Ensemble Deep Learning

Emily Diegel

Embry-Riddle Aeronautical University

Neural networks are an emerging topic in the data science industry due to their high versatility and efficiency with large data sets. The purpose of this modern machine learning technique is to recognize relationships and patterns in vast amounts of data that would not be explored otherwise. Past research has utilized machine learning on experimental data in the material sciences and chemistry field to predict properties of metal oxides. Neural networks can determine underlying optical properties in complex images of metal oxides and capture essential features which are unrecognizable by observation. However, neural networks are often referred to as a "black box algorithm" due to the underlying process during the training of the model. The explanation for a prediction is unable to be traced, therefore poses a concern on how robust and reliable the prediction model actually is. Building ensemble neural networks allows for the analysis of the error bars of the prediction model. The project's objective is to determine the comparative differences between the predictive ability of each individual neural network versus the ensemble neural network. Additionally, the paper explores how to use the ensemble model as a method of uncertainty quantification. Overall, ensemble neural networks outperform singular networks and demonstrate areas of uncertainty and robustness in the model.

Abstracts of Posters

Basketball Network Visualization and Analysis

Calvin Finley & Juliana Horvath

Florida Gulf Coast University

To measure the effectiveness of player combinations and how players contribute to scoring plays, we create and analyze weighted graphs for National Basketball Association (NBA) teams in the 2021-22 season using play-by-play and other advanced data gathered from NBA.com. Each node in a team's graph represents a player on that team, and the presence of an edge between two nodes means that the two respective players played together at some point in the season. The weight of an edge is equal to the points scored per minute by either of an edge's players while the two were on the court at the same time, and we analyze these weights for two-person lineups to determine the players that work best together. Lastly, we use existing algorithms to generate metrics for teams' scoring graphs as they changed over the course of a season, leading to the creation of moving average visualizations and comparison of teams' abilities.

Predicting Flight Time Using Machine Learning Methods

Ioannis Parascho

Embry-Riddle Aeronautical University

Partnering with OneSky Flight, this project aims to develop a flight time predictor using various machine learning methods. Six months of flight data was provided by OneSky Flight; it included attributes such as origin, destination, aircraft type, departure time, and arrival time. The two primary methods tested were neural networks and decision trees. Each method was tested with varying architectures and data structures to determine accuracy. The resulting analyses of the architectures found the XGBoost decision tree to be the highest performing model. Using the results of the architectures, an ensemble model can be developed that incorporates the use of both neural networks and decision trees to further increase the accuracy of the predictor.

Reinforcement Learning For Bitcoin Portfolio Optimization Using Historical And Synthetic Data

Neila Bennamane

Florida International University

Given a cryptocurrency, this paper aims to find the best approach in modeling the price in order to optimize the portfolio according to the price changes of its current inventory over time. There exists a pattern within the data which will allow us to predict which action (buy/sell/hold) to take regarding each asset in the portfolio in order to optimize returns through minimizing risk and maximize profit. Data will be modeled using sequential modeling, probabilistic sequence modeling, and advanced neural networks to create a decision making process with reinforcement learning. The machine learning algorithm will utilize the different models efficiently to ultimately decide the best course of action that can be taken, given an asset with respect to time in order to optimize the rewards function.