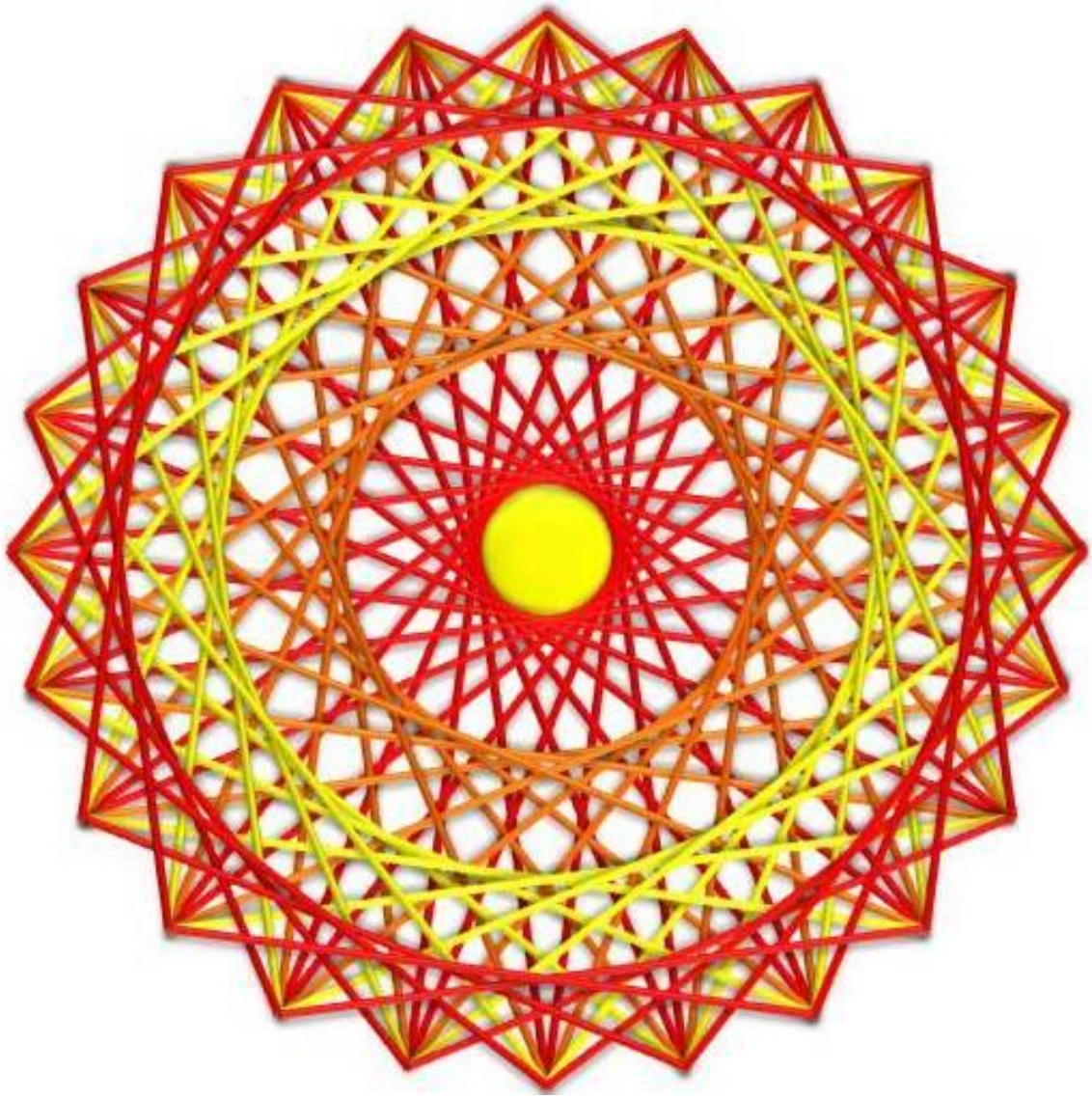

CAARMS22

Student Poster Abstracts

Princeton University / Institute for Advanced Study

June 15th-18th, 2016

1. Danisha Baker

Florida State University

Random-Effect Modeling for Longitudinally Observed Skewed Heteroscedastic Response: A Bayesian Wavelet Based Approach

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In this paper we propose a random effects based model for partial linear median regression function of a skewed longitudinal response using a wavelet based tool for the nonparametric part of the regression function. Parameters are estimated via a semiparametric Bayesian estimation procedure using an appropriate Dirichlet process mixture prior for the skewed error distribution. Unlike common practices for wavelet based regression for equally spaced data, we use a hierarchical mixture model as the prior for the wavelet coefficients. For the ''vanishing'' coefficients the model includes a level dependent prior probability mass at zero. This practice implements wavelet coefficient thresholding as a Bayes Rule. Consistency results have been obtained with only minor regularity conditions on the tail of the skewed and unimodal residual density. Practical advantages of our method are illustrated through a simulation study and via analysis of a cardiotoxicity study of children of HIV infected mother.

2. Ivor Blackman

CUNY Medgar Evers College

Conjugation Invariant representations of the Generalized Symmetric Group

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Let K/F be a finite extension of finite fields. The Shintani lift is a bijection between irreducible representations of $GL(n,F)$ and conjugation invariant representations of $GL(n,K)$. We classify irreducible “conjugation invariant” representations of the *generalized symmetric group*. This can be thought of as a generalization of the Shintani lift to the case of the “field of one element”.

3. Frederick Campbell

Rice University

Sparse Higher Order Partial Least Squares for Brain Decoding Using Electrocorticography Data

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We propose new statistical methodology for the brain decoding problem using electrocorticography (ECOG) data. This is large, high dimensional, neuroimaging data with complex dependencies between variables. We seek to accurately classify patient stimuli using a novel tensor decomposition that exploits the structure inherent to ECOG data. To this end, we introduce the Sparse Functional Higher Order Partial Least Squares method for classification and dimension reduction. To evaluate the effectiveness of our method we compare the classification accuracy achieved using the Sparse Functional Higher Order Partial Least Squares method with common machine learning and classification methods. In addition to accurately identifying patient stimuli, our method identifies relevant regions of the brain and their respective activation times showing that our method is competitive for classification tasks while being much more interpretable then existing statistical methods for analyzing ECOG data.

4. Jayshawn Cooper

Morgan State University

Geometric and Computational Representation of Surfaces and Their Topological Characterization as Quotient Spaces

In this project we explain and logically derive the parametric equations of various surfaces including most notably the Mobius strip and the Klein bottle. We do this by mapping rectangles in the *u*-*v* plane ($\mathbb{R}^2$) onto the surfaces in $\mathbb{R}^n$ (n = 2, 3, 4). While well-known in the literature, we discovered these formulas and explanations independently in an Inquiry Based Learning (IBL) project. We then, with the help of computer graphics present these surfaces visually. Lastly, we study their topological properties as quotient spaces, proving that the images in $\mathbb{R}^n$ (n = 2, 3, 4) are homeomorphic to quotient spaces of the unit square with identifications of boundary points.

This is joint work with mentor, Marshall M. Cohen of Morgan State University.

5. Jared Day

City College of New York

Microcavity Enhanced Second Harmonic Generation of MoS_2

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Two dimensional semiconductor materials promise to be nanometer-scale building blocks for next generation opto-electronic technologies because of their novel optical properties such as valley dependent emission, strong photoluminescence, and giant nonlinear response. We show the nonlinear efficiency of monolayer MoS_2, can be enhanced by embedding MoS_2 within an all-dielectric Fabry-Perót microcavity. Power dependency shows a 10-fold increase in second harmonic generation when the embedded 2D material is resonantly enhanced at the pump wavelength matching theoretical estimate.

6. Daniel Eckhardt

Rensselaer Polytechnic Institute

Suppression of the Magnetorotational Instability

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Magnetorotational Instability (MRI) is an instability that is responsible for accretion, the phenomenon observed in astrophysical flows, for example around black holes. MRI can be modeled using equations of nonlinear PDEs derived from conservation laws. A typical linear analysis of these equations makes what is known as the small magnetic Prandtl number approximation, which results in dropping one of the terms in these equations. This dropped term represents the twisting of radial magnetic components into azimuthal ones. We prove here that the MRI is suppressed when this term is dropped. We recast these equations using abstract differential operators to model the different boundary conditions associated with the problem, and use the method of positive operators to prove that these operators are positive, and hence the instability is suppressed. This work was done with Professor Isom Herron (RPI) and Professor Jeremy Goodman (Princeton University).

7. Olaseni Fadipe

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College Students' Awareness of Quantitative Information

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This study addresses one part of a larger dissertation study on "The Development of Quantitative Literacy in College Students." It examines college students' awareness of the quantitative information that surrounds them.

Twenty-one students participated in the study including seven anchor participants who took part in three rounds of in-depth qualitative interviews. Five of these interviewed participants reported that they are now more aware and more critical of the quantitative information they encounter in news and social media.

Furthermore, the 194 mathematical journal entries of all the participants also show that more than half of them are now more quantitatively aware. For example, more than 100 of their journal entries involve finances and evaluation of numerical information found in news media. Overall, the participants believe that they are now more equipped with the basic mathematics concepts they need to read, understand, interpret, and manipulate quantitative information.

8. Paul Fomenky

University of Massachusetts Boston

A Matrix Factorization Approach to Predicting Successful Commercial Real Estate Development Partnerships

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Proposed commercial real estate development projects have a significant impact on the current and future landscape of cities. Despite the high completion rates of projects, a significant number go uncompleted with significant ramifications to cities' economies.

In this paper, we propose a recommender systems based algorithm to predict the completion rate of projects proposed by developer, architect pairings. We recast the problem as the following recommender systems question - at what rate will the pairing of an owner and an architect lead to completed projects? Equivalently, we ask - how does an owner rate an architect? Matrix Factorization via stochastic gradient descent is shown to learn the completion rates of project collaborators. Methods in mining imbalanced datasets are also used to boost the accuracy of the algorithm. Experiments on a real dataset show a 44% improvement over assuming (as currently is the case) that every pairing will be successful. The method red flags several projects of high economic value.

The main contribution of the paper is the usage of collaborative filtering and imbalanced dataset techniques in the mining of commercial real estate data.

9. Charles (CJ) Hardnett

Rockdale Magnet School for Science and Technology

Robotics in the Navy: Extinguishing Fires on Aircraft Carriers

The goal of this experiment is to test the ability for robots to communicate using Bluetooth and be able for the sender to read a color value or an RFID value and send that value to the receiver and then the receiver report to the designated location that it was sent. It will then be able to use an infrared sensor to be able to find an infrared ball that emits infrared light.

For the color test, there will be 2 NXT Lego Robots used, the sender and the receiver. The sender will send the receiver a message that is a number that will be representing a color on a mat with 9 different colors on it. The number sent also represents, theoretically, where the fire on the carrier is located. Based on the number it was sent, the robot will choose one of the programs in its system to find the quickest way to get to the “fire”. For the RFID test, there will be 2 NXT Lego Robots as well, the sender and the receiver. The only difference between this test and the color test is the fact that the sender will be sending the robot a radio frequency number such as .7786543902 and the receiver will be picking a program to find the quickest way to the RFID tag (where the fire is located) that it was sent.

The goal of the experiment was accomplished. The robot was able to locate the zone of the fire and then locate the direction of the fire in both the color sensor and the RFID sensor tests. As an actual product, the robots would not be made out of Legos, but instead with a durable metal. It will probably use RFID to find the zone of the fire, as colors can lose their pigments over time and can become dirty. There would also not just be finding the location of the fire, but it would also be able to extinguish a fire using a hose or another method of suppression. The target demographic for this product is the Military and also homes in which people who aren’t able to extinguish fires aren’t in danger. There would be two logos: one being would be a robot extinguishing a fire with a soldier in the background, and the other being a robot extinguishing a fire with a family in the background. The next step is to actually build a robot that is able to find the location of a fire in a house or school from scratch using durable metals and an Arduino.

10. Erin Hardnett

Rockdale Magnet School for Science and Technology

V.I.B.E.S. Technology: Saving Lives with Algorithms

Visual impairment is defined as a loss of vision. Many people worldwide are visually impaired. In fact, approximately, 10 million people are visually impaired in the United States alone (KidsHealth, 2012). Because of this amount of people, many devices and objects have been used in order to help them in their daily lives, including seeing-eye dogs and canes (American Foundation for the Blind, 2014). But, what if they were stuck in an unfamiliar building and did not know how to get out?

V.I.B.E.S. Technology stands for *Visually Impaired Building Evacuation System*. This mobile device application uses Floyd-Warshall's shortest path algorithm to help a visually impaired person navigate out of a building in case of an emergency, such as a fire.

The program works by taking the formula, (L/8)-1, and using the floor plan with the certain lengths of the hallways that are in the adjacency matrix. The administrator just has to take a sketched floor plan of the building and put it into the system by scanning it in. After that, the system will ask for the measurements of each hallway. The numbers represent the lengths between the points on the weighted graph, but the system won't need it to be that specific. Just the overall distance of each hallway will be needed. Then the system will calculate the number of beacons necessary using the formula previously stated.

11. Kingsley Iyawe

Morehouse College / SPIRAL

Bernie Sanders and the Black Vote

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This project focuses on Democratic Presidential Candidate Bernie Sanders and his struggle in obtaining the minority vote. While Sanders has attracted the white vote, the Independent vote, and the youth vote, he's struggled heavily with minorities, especially Blacks. Another reason Bernie Sanders is losing to Hillary Clinton in the election is because he cannot win a specific region that helped Barack Obama defeat Hillary Clinton in 2008, the South. According to the U.S. Census, eight of the top ten black population states are located in the South. Bernie Sanders lost all eight states to Hillary Clinton in 2016, while Barack Obama won all eight states against Hillary Clinton in 2008. The project focuses on cities with large majority populations in states where Sanders won and lost. After finding the data, we compare the results to Barack Obama's performance in the same cities against Hillary Clinton by using tables, bar graphs, and count data.

12. Ethan Jackson

American University / SPIRAL

An Exploration of Electronic Synthesizers

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The electronic synthesizer is a commonly used piece of equipment to create music and the instrument itself has grown in the music industry. This paper will include and describe how the electronic synthesizer involves sound waves, sound production and electricity. The details and information revealed will be in relation of audio technology, this paper will allow students and musicians to explore and be informed of the basic science and physics behind the instrument. Using key information of audio technology, the basic and advanced parts of the synthesizer will be covered such as its functions involving filters, amplifiers and oscillators.

From sound waves and electric currents to the sound effects in the genre of dubstep, the main physics of sound is applied to the electronic synthesizer. Whether a musician or not, knowing the functions of this instrument is a good way to explore the physics of sound and electricity. Knowing the internal and external functions of the synthesizer can help one gain knowledge of basic physics of sound. Breaking down electric science of the synthesizer will leave one knowing not only what the instrument does it self, but why the instrument can make generated audio transform into music.

13. Caprichia Jeffers

Emory University

A Bayesian Zero-Altered Poisson Graphical Model for Identifying Functional Co-Activation Patterns

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Meta-analysis of functional neuroimaging data has become increasingly important recently. Much attention has been paid to detect consistent activation regions or locations across independently performed studies, while very limited works have been focusing on co-activation pattern identifications. To fill this gap, a Poisson graphical model (Xue et al, 2014) was proposed and the penalized likelihood approaches along with EM algorithms have been developed to make model inference. However, this method is not applicable when the number of activation points is sparse over the brain regions. To mitigate this problem, we propose a Bayesian zero-altered Poisson graphical model for which we introduce a new prior model for the intensity parameters in a two-part multivariate Poisson distribution. We develop efficient posterior inference for more accurately estimating the co-activation patterns and the associated brain network. We illustrate our methods via extensive simulation studies and a meta-analysis of functional neuroimaging data for emotion studies.

14. Patrick Jefferson

Harvard University

Negative Branes, Supergroups and Spacetime Signature

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Negative branes, extended objects with negative charge and tension, were initially introduced as a means to realize supergroup gauge theories in string theory. It was recently proposed that the inclusion of these objects in string theory can dynamically change the signature of spacetime. I will introduce negative branes and briefly discuss their connection to all possible spacetime signatures consistent with supersymmetry.

15. Nonhle Channon Mdziniso

Central Michigan University

The Quotient of the Beta-Weibull Distribution

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A new class of distributions recently developed involves the logit of the beta distribution. Among this class of distributions is the beta-Weibull distribution developed by *Famoye et al.* (2005). Many useful statistical properties arising from these distributions and their applications to real life data have been discussed in literature. In this work, the quotient of the beta-Weibull distribution is defined and studied. Various statistical properties of the distribution are provided, including moments, skewness, kurtosis, asymptotic behaviors, and Rényi entropy. The method of maximum likelihood estimation is proposed for estimating the model parameters. Results show that the quotient of the beta-Weibull distribution may be appropriate in modeling events where infant mortality failures are occurring.

16. Charles Njoroge

Brown University

A Review of 3D Mapping with Robots

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Rangefinding is a game changing technology that is now enabling robots to build increasingly accurate and high-resolution 3D maps. Such maps enable robots to autonomously navigate space without collision and detect objects for dexterous manipulation. I will provide a review of basic spatial mapping for robots and its use of linear algebra and quaternions. This review will also include methods for loop closure optimization and presentation of results from robotic spatial mapping.

17. Lexi René

Emory University, Rollins School of Public Health

30-day Hospital Readmission of Georgia Lupus Registry Systemic Lupus Erythematosus Patients

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Systemic lupus erythematosus (SLE) is a chronic, autoimmune disease, in which a cure has yet to be found. This type of lupus mistakenly allows the body's immune system to attack healthy tissue, which affects many parts of the body with mild or serious symptoms. Although there is no cure, SLE can be effectively treated with drugs. Due to the physical, as well as, psychological burdens that are associated with this disease, SLE inhibits people from completing their daily tasks; i.e., going to work/school. Because of this employment and insurance become difficult to maintain. Many SLE patients are insured by Medicare and Medicaid. Having SLE can lead to frequent utilization of health services with significant financial impact.

The Georgia Lupus Registry (GLR) conducted surveillance of SLE patients in Atlanta to develop a population- based registry geared towards better defining the incidence and prevalence of lupus. Supplementing the GLR data with Georgia Hospital Discharge Data provided insight into hospital utilization and readmission. Patients were categorized into three groups: never hospitalized, hospitalized with no readmission within 30 days and hospitalized with readmission within 30 days. Factors associated with 30- day hospital readmission and utilization of hospitals among SLE patients were examined. Time to first hospital readmission within 30 days and associated baseline factors were analyzed.

Multivariate analyses showed that patients who live in census block groups with lower income, and patients that meet the pleuritis/pericarditis American College of Rheumatology criteria should be paid extra attention upon being hospitalized. The odds of readmission within 30 days are higher for patients in those two categories ($p = 0.001$, $p = 0.003$; respectively). These patients are also of higher risk for readmission within 30 days ($p = 0.003$, $p = 0.002$; respectively).

18. Laura M. Roberts

Princeton University

Traffic Correlation Attacks Using DNS

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Tor is a very popular anonymity network that is known to be susceptible to end-to-end traffic correlation attacks that can be performed by network-level adversaries such as ASes and IXPs. Previous work on such attacks has focused on the TCP streams while the accompanying DNS traffic has been completely ignored. In our work we study the nature of DNS resolution in Tor and how DNS traffic can be used by network-level adversaries to deanonymize Tor traffic. For example, we are investigating how DNS traffic can be used to boost the success of website fingerprinting attacks. Our contributions include drawing attention to the role DNS can play in Tor deanonymization attacks and improving upon earlier Tor measurement techniques in order to produce results and estimates that are more practical and realistic.

19. Carlos Samuels & Damar Saul

Medgar Evers College

Computing Commuting Partitions

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A square matrix N is called nilpotent if $N^k = 0$ for some positive integer k. By the Jordan Normal Form Theorem, the conjugacy classes of nilpotent $n \times n$ matrices are in one-to-one correspondence with the partitions of n. We say that two partitions P and Q of n commute if there is a nilpotent matrix A of partition P and nilpotent matrix B of partition Q such that $AB = BA$.

In this undergraduate research project, we are using the open-source mathematics software system *Sage* to find all the partitions that commute with a partition $P = (u, u - r)$ where $u > r > 1$.

20. Munira Shahir

University of Maryland, Baltimore County

Data Based Behavior Modeling in DOTA2

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In our project, we used data from the multiplayer online battle arena (MOBA) game Defense of the Ancients 2 (DOTA2) in order to develop a data driven behavioral model and predict a player's next behavior. Based off of the data gathered from dotabank.com, we developed a Classification and Regression Tree (CART) model that gave us the player's next location and action state. Utilizing inputs such as the character's levels, number of kills, last hits, and deaths of the character we predict the aforementioned player behaviors. Overall, we found that this model performed well on common player actions and gave good approximations of a player's locations.

21. Cleveland Waddell

North Carolina State University

Rational Function Vector Recovery With Error Correction by Parametric Linear System Solving And Cabay Termination

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We would like to recover a vector of rational functions, in a single parameter u over a field K, from as few evaluations of the vector as possible, given that no more than E evaluations are wrong. Our vector of rational functions,

$$\mathbf{f}(u)/g(u) = \begin{bmatrix} f^{[1]}(u)/g(u) \\ \vdots \\ f^{[n]}(u)/g(u) \end{bmatrix}$$

has $g(u)$ monic and GCD $(f_1, f_2, \ldots, f_n, g) = 1$. We consider solving systems of the form $A(u)\mathrm{x} = b(u)$, where the entries are polynomials in u over K, and $A(u)$ has full rank. We prove that we can solve such a system as long as on enough evaluations we have a scalar system, possibly unrelated to the evaluated system, that has as its solution, the evaluated solution of the system. Our algorithm can be specialized to recovering $f(u)/g(u)$ from its evaluations.

We ignore evaluations that cause a drop in rank and use error correcting code techniques to find the solution. Our initial algorithm is a generalization of Welch/Berlekamp decoding of algebraic Reed/Solomon error correcting codes. We describe when it is possible to use fewer evaluations than Welch/Berlekamp. Our algorithms work even if some evaluations are roots of the denominator. We also describe a general early termination algorithm that allows us to compute the solution from fewer evaluations if our degree bounds grossly overestimate the actual degrees.

22. Jonathan W. Welburn

University of Wisconsin – Madison

Economic Contagion and the Role of Beliefs: Findings from a Borrower-Lender Game

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Following the 2007 global economic crisis, IMF chief economist Olivier Blanchard stated that "we have entered a brave new world…The economic crisis has put into question many of our beliefs. We have to accept the intellectual challenge." Recent crises – the 2007 crisis, the 2010 European debt crisis – have drawn a new landscape for how we view economic crises. They have elucidated the systemic nature of economic risk, where adverse economic events are able to spread from one country to the next through a process known commonly as contagion. The term "contagion" implies the infectious spread of economic malaise from a single source country outward. Debt and trade channels might explain an outward propagation of crises. However, the appearance of contagion may also result from the effect of a common cause. The complexities of these crises and the challenges they present have motivated the application of operations research, risk analysis and economics to a problem that is fundamentally economic in nature, but generates questions which an interdisciplinary approach may help to answer.

We present a within-period sequential-move game with multiple borrower countries and a single common lender to model cross-country contagion. We discuss the role of beliefs, modeled through Bayesian updating, and determine equilibrium solutions using nonlinear optimization. The model is calibrated to the 2010 Eurozone crisis, but sensitivity analysis is used to identify conditions under for contagion. Results demonstrate the importance of beliefs and that what appears to be contagion may be the result of a crisis of confidence. Findings and their policy implications are discussed.

23. Alexis White

American University

An Exploration of Voter Identification Laws on the Impact of Voter Awareness

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Over the last decade, voter identification laws have been a highly debated issue. In the aftermath of the controversial 2000 primary elections, states across the country have tightened voting laws to require voters to present some form of identification, either documents or photo. The changes in the laws led to a controversial partisan between political parties. Supporters argue that these laws are necessary to reduce and prevent voter fraud. Opposing arguments suggest the new changes are prejudice toward the poor, the elderly and minorities based on the rarity of voter fraud.

With the ongoing debates regarding the impact of voter legislation and the lack of empirical findings to support either argument, we sought to perform an empirical analysis to examine any marginalization that may exists due to new voter identification laws. The purpose of this study was to analyze the impact of the new Virginia voter identification laws on voter awareness in Northern Virginia and investigate areas in which attaining voter identification might be difficult.

24. Timothy Woods

Pomona College

Mathematical Modeling of Cancer Cells: A Closer Look at the Effects of PD1-PDL1 Immune Inhibitory Blocker on Cancer Vaccines

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Immunotherapy is an emerging cancer treatment used to boost an individual's immune response to their own specific cancer type. We develop a mathematical model to assess the interaction between dendritic cells, tumor cells, and effector immune cells. This model consists of a system of differential equations describing the cell populations and their interactions. This work builds on a previous model that illustrated the effectiveness of dendritic cancer vaccines by providing us with approximate dosage timings for patients. There is ongoing research that suggests that a Programmed Death -1 (PD1) and its ligand PD-L1 have a significant impact on the suppression of effector immune cells and the increased proliferation of its antagonist, tumor cells. This, in turn, diminishes the effectiveness of the vaccine on treatment outcomes. Our goal is to enhance the previously constructed model by introducing new variables to represent PD1-PD-L1 and the blocker. Our hope is to determine the sufficient dosage and treatment protocols to provide patients with optimal outcomes.

25. Derek Young

Iowa State University

Lower Bounds for the Exponential Domination Number of $C_m \times C_n$

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This poster will discuss the exponential domination number for the graph $C_m \times C_n$. In the paper, *On Exponential Domination of* $C_m \times C_n$, Anderson et. al. proved that $\frac{mn}{15.875}$ is a lower bound for the exponential domination number of $C_m \times C_n$. We use linear programming to sharpen the lower bound to $\frac{mn}{13.7619+\varepsilon}$.