The Eighteenth Annual Nebraska Conference for Undergraduate Women in Mathematics

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POSTER ABSTRACTS

Posters by Undergraduate Students

Rebekah Aduddell, Texas Lutheran University
Morgan Ascanio, University of Washington Bothell
[A][1] *Unilateral and Equitransitive Tilings by Equilateral Triangles of n Different Sizes*

A tiling is said to be unilateral if no two equal sides of polygons meet corner to corner and equitransitive if any tile can be mapped via a symmetry of the tiling to any other congruent tile. It has been shown that a unilateral and equitransitive (UE) tiling can be made with any arbitrary number of squares. We have shown that there are exactly two UE tilings by equilateral triangles: one with two sizes of triangles and one with three sizes of triangles.

Amanda Alexander, Western Washington University
[B] *Impact of Calcium Store Overload on Electrical Dynamics of Cardiac Myocytes*

Heart disease is the leading cause of mortality in the United States. One cause of heart arrhythmia is calcium mishandling in cardiac muscle cells. We present a mathematical model of the mechanism by which calcium waves propagate through these cells accounting for changes in the calcium concentration of the SR, the effects of buffers in the SR, and the effects of voltage differences across the cell membrane. We found that incorporating a dynamic SR calcium concentration causes the flux of calcium through open CRUs to taper off over the duration of the CRU firing, lowering the likelihood of waves to propagate. Likewise, including the effects of calcium buffers in the SR decreases the free calcium concentration, again decreasing the likelihood of waves to propagate. Additionally, voltage-gated channels are utilized to examine the impact of voltage on calcium dynamics, with results indicating that an increased voltage difference across the cell membrane causes more calcium to be released into the cell.

Morgan Ascanio, University of Washington Bothell
[A] see **Rebekah Aduddell**

Bethany Barber, Creighton University
[A] *Vanishing Viscosity Limits for the Lagrangian Averaged Navier-Stokes Equation*

The Lagrangian Averaged Euler and Lagrangian Averaged Navier-Stokes equation are recently derived approximations to the Euler and Navier-Stokes equations, respectively. As the name suggests, the Lagrangian Averaged Navier-Stokes equation is derived by averaging at the Lagrangian level, and the resulting partial differential equations have more easily controlled long time behavior at the cost of a more complicated non-linear term. In this project we consider the vanishing viscosity problem for circularly symmetric flows.

[1] [A] indicates poster session "A", [B] indicates poster session "B".

Kristina Bell, Slippery Rock University
Kallie Simpson, Slippery Rock University
[A] *Cluster Analysis of Pedagogical Methods*

In recent years, there has been a debate in the education field regarding the success of using "flipped" classrooms as a new teaching pedagogy. Flipped learning is defined by flippedlearning.org to be, "a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment..." The lack of published literature regarding this topic is hindering the improvement of the learning process. The purpose of our study is to perform cluster analysis on the graded material from Elementary Statistics 1 taught in regular and flipped classroom settings at Slippery Rock University to identify clusters that might give insight into the two different teaching pedagogies. These classes include a variety of majors, class status', genders, and evaluation methods. We are concentrating on Hierarchical and K-Means cluster analysis through the use of R software.

Iris Bennett, Grinnell College
Zaynab Diallo, Iowa State University
[A] *Features of Carbon Nanotubes*

Carbon nanotubes are cylindrical structures made from carbon atoms that are only billionths of a meter in diameter. Though they have only been widely studied since 1991, carbon nanotubes have already been incorporated into a variety of industries for the improved strength, conductivity, and resilience they offer over other materials. At a submicroscopic level, these nanotubes can be classified into three distinct types which are differentiated by their amounts of curvature and bundling. However, there is no concrete method of classification for these types. Our goal was to extract information from images of carbon nanotubes about characteristics such as bundling and curvature and look at relationships between factors and their resulting varieties of nanotubes. To do this, we used supervised classification methods such as random forests and logistic regression to classify these images into the three types and use various measures to see how well our model fit.

Rebekah Bright, Slippery Rock University
[B] *Of a Problem from the New York Times Column Number Play*

"Suppose that n children are standing in a circle playing the following game with a ball. The first person tosses the ball to the person on his right, that person tosses the ball two spots to the right, that person tosses the ball three spots to the right, etc. For which values of n will all n children touch the ball?" This problem may be formulated in the language of mathematics as follows: For each positive integer n, let $tn = [n(n+1)]/2$, be the nth triangular number. We show that the set of residue classes $\{[ti]n \mid 1 \leq i \leq n\}$ is a complete residue system if an only if n is a power of 2.

Ella Burnham, St. Catherine University
[A] *Parameter Estimation in Continuous Time Markov Chain Models using Extended Kalman Filtering*

The Extended Kalman Filter (EKF) was applied to estimate parameters for a Continuous Time Markov Chain (CTMC) model. The EKF approximates nonlinear systems locally as linear systems and then uses both the data and model to potentially gain a more accurate prediction for the system than with the data or model alone. This method also takes into account the covariance in the data measurements, as well as the covariance in the model output. By treating the parameters of the stochastic model as time dependent variables, we can use EKF as a parameter estimation technique. We implemented this technique on a SIS-epidemic model. Given data from a CTMC model, we compared applying EKF for parameter estimation to an alternative approach involving minimizing an ordinary least squares cost function using a deterministic approximation of the CTMC model.

Karen Butt, University of Chicago
[B] *The Gauss-Bonnet Theorem*

We prove the Gauss-Bonnet theorem, which relates a compact surface's Gaussian curvature to its Euler characteristic. We show the Euler characteristic is a topological invariant by proving the theorem of the classification of compact surfaces. We use the Gauss-Bonnet theorem to give a geometric proof of the Poincare-Hopf index theorem, which relates the index of a tangent vector field on a surface to the surface's Euler characteristic.

Xi Chen, University of Rochester
[A] *Cores of Alexandroff Spaces*

Following Kukiela, we show how to generalize some results from J.P. May's book, *Finite spaces and larger contexts*, concerning cores of finite spaces to cores of infinite Alexandroff spaces. It turns out that finite space methods can be extended under certain local finiteness assumptions. In particular, every bounded-paths space or countable finite-paths space has a core, and two bounded-paths spaces or countable finite-paths spaces are homotopy equivalent if and only if their cores are homeomorphic.

Taylor Chott, Colorado School of Mines
Carrie Kralovec, Colorado School of Mines
[A] *Ginger Genetics*

Are gingers truly going extinct? With this question in mind, we attempt to model redhead populations. Red hair comes from a mutation in the MC1R gene receptor, causing a recessive gene. The gene variations can result in no mutation (non-redhead), one recessive allele (carrier), or a double recessive allele (redhead). The behavior of these cases is modeled with Hardy-Weinberg genetics, discrete difference equations representing generations of the populations. This basic setup expands to incorporate genetic preference. To accomplish this, we add a mating preference parameter. This parameter varies to indicate preference in mate selection; the larger the value, the stronger preference for a mate of similar phenotype. This new model is then applied to various countries of interest with large redhead populations. Through these manipulations, we search an answer to the question of whether or not gingers are going extinct by analyzing how these models affect the end population balance of the MC1R gene mutation.

Aurea Colston, California State University, Sacramento
[B] *Applying Graph Theory to Time Series Analysis*

We built a time series visibility (TSV) graph from successive sections of a time series. Since each section had a variety of data points, we divided the average degree of the TSV graphs by the number of data points to produce a density measurement. We first simulated data using the Lotke-Volterra model and looked for changes in the density of each section. In one of our models, the computer randomly selected the timestep 4434 to change the underlying constants. By looking at the density measurements from the TSV graphs, we were able to predict that the change occurred between timesteps 4200 and 5000. We then experimented with real data. Since the real data was very messy, we smoothed the time series using averaging. We found that around year 2000, the density decreases significantly. However, the changes were not as clear as the simulated data. We hope to, in the future, find more sophisticated ways to filter the data to allow the technique to work on real life data.

Sheri Cope, Youngstown State University
[B] *The Fifteen Schoolgirl Problem*

The Fifteen Schoolgirl Problem asks how one can arrange fifteen schoolgirls in five rows of three for seven consecutive days such that each pair of girls has walked out in the same row exactly once at the end of the seven days. We will look at a brief introduction to Projective Geometry and the Fano plane as these motivate a solution to the problem. Additionally, we will define Steiner triple systems and Kirkman triple systems and see how the Fifteen School Girl Problem can be solved using them.

Kathryn Coulter, Stetson University
[A] *Tracking the Untrackable: A Social Network Analysis of ISIS Recruitment Using Twitter and R*

The rise of non-state actors and globalization in the international system presents clear challenges to the historical methodology on power, legitimacy, and decision making. Terrorist groups like ISIS have since found new means to establish legitimacy in their control and power. Among their most successful techniques is the use of social media,particularly Twitter, to recruit and spread propaganda. Social network analysis and text analysis can provide frameworks to uncover why ISIS uses Twitter and can identify key trends in how they reach prosperity so an attempt at countering their momentum can be made. In this research, tweets pertaining to ISIS are analyzed in the hope to investigate their recruitment strategies and techniques.

Lindsay Czap, Grand Valley State University
[B] *Minimizing the Cost of Guessing Games*

A two-player guessing game is a game in which the first participant, the Responder, picks a number from a range. The second participant, the Questioner, asks yes-or-no questions in order to guess the number. The Responder may lie in their responses during a guessing game. A guessing game that can correct for lies is an error correcting code, a mathematical object which can detect an error in the information that we receive and correct them. We will give definitions in coding theory and show how error correcting codes allow us to still guess the correct number even if one lie is involved. We will introduce cost functions to guessing games. Each of the possible answers are assigned a price. The Questioner will be charged the cost of all of the possible answers that they are asking about. We will discuss methods for minimizing the total cost of a guessing game with a cost function. We proved that, given any cost function, the most cost efficient guessing game takes the form of one of two game constructions.

Mai Dao, Texas Tech University
[A] *FPGA Implementation in Complex Math Solver Algorithms*

Field-programmable gate arrays (FPGAs) are very flexible computer chips, and they are used to enhance the performance of complex mathematical solvers. The Verilog language for Xilinx is used to write parallel hardware Conjugate Gradient implementations that execute numerical methods like the Finite Difference Methods and Finite Element Methods. Such methods can be used to solve various partial differential equations like fluid dynamics, heat transfer, and Laplace transformation equations and to locate the areas of possible solutions for various linear systems. Not only has the cost of such technologies been greatly reduced in recent years, but this method is also super fast and can present novel approaches to complex mathematical challenges. We will describe a systematic review of innovations in the world of complicated equations solvers using FPGAs.

FranChell Davidson, Texas Southern University
[B] *Dynamics of a Mathematical Model for Four-State Perceptual Rivalry*

Binocular rivalry occurs when two disparate images are presented to different eyes simultaneously. Instead of seeing two images superimposed, one experiences perceptual switching between different images instantaneously. Binocular rivalry is one class of multistable perceptual rivalry. Such dynamic perception under a constant stimulus makes multistable perception ideal for studying visual awareness and its underlying cortical mechanisms. A huge body of literature has devoted to the bistable rivalry. However, only a few work considered multistable perceptual rivalry. Here we study a model a slow-fast system proposed to account for four-state binocular rivalry observed in several sets of experiments. We find that the four percepts correspond to four steady states of the fast system, and the slow process (adaptation) and noises are needed to drive the switches.

Megan Davis, DePaul University
[A] *Real-Time Bidding Optimization for Online Advertising*

In the online advertisement industry, real-time bidding (RTB) is a mechanism for filling advertisement space on websites. A representative of the website contacts a sell-side platform who holds a second-price sealed-bid auction real-time to sell the ad space to a select number of advertisers. Sell-side platforms are interested in choosing the revenue-maximizing floor price for each auction. During RIPS IPAM 2015, our team established two distinct learning models to choose these revenue-maximizing optimal floor prices. The algorithms observe the highest bids received from previous auctions and constantly update an optimal floor price. Both algorithms are performed on different groups of impressions to ensure proper product-differentiation. To assist in the efficiency of product-differentiation, we propose potential clustering methods of impression types. After we developed our optimization schemes, we ran each algorithm on simulated RTB environments to demonstrate their effectiveness.

Jessica Deters, Colorado School of Mines
[A] *Genghis Khan: Quantifying his Influence*

This project examines the patriarch of the Mongol Empire, Genghis Khan, in order to estimate the potential number of women that carried a child fathered by Khan. This project used current estimates of the number of Khan's living descendants and went backwards to estimate how many women Khan impregnated, assuming each woman had only one child by Khan. We aim to provide a new measure of the extent Genghis Khan's influence as well as to emphasize the interdisciplinary relationship between mathematics and the social sciences.

Robin DeVries, Metropolitan State University Denver
[B] *Modeling the Diffusion of Morphogens in Syncitial Embryos*

Morphogens (a term coined by mathematician Alan Turing) are a class of diffusable molecules that pattern whole tissues and multi-cellular structures in developing embryos. *Drosophila melanogaster*, the common fruit fly, has a multi-nucleated embryo that allows for large-scale diffusion of morphogens. Sufficient data exists to begin crafting mathematical models to make better predictions and simplify future study in the laboratory. The diffusion partial differential equation (first developed by biologist Adolf Fick) has been used to model the diffusion of Bicoid protein, a morphogen that organizes anterior boundaries of the *Drosophila* embryo. Assuming a steady-state solution to the diffusion equation, I have developed a system of equations for the morphogens involved in establishing the anterior-posterior axis of the head, thorax, and abdomen gradients. Using Euler's Method, I begin exploring the rates of change within the diffusing system.

Zaynab Diallo, Iowa State University
[A] see **Iris Bennett**

Rachel Eaton, United States Air Force Academy
[A] *Numerical Semigroups and the Sylver Coinage Game*

Sylver Coinage is a game for two players. The first player picks a positive integer n_1. The second player picks a positive integer n_2 which cannot be a multiple of n_1. Game play consists of each player picking a new integer which cannot be expressed as a linear combination of any integers which have been picked. The player who picks 1 on her turn loses. We will be examining this game's connection to numerical semigroups and trying to determine a game-winning strategy.

Megan Feichtel, Davidson College
[B] *Universal Hash Functions*

This poster will discuss the uses of universal hash functions in applied mathematics and computer science and walk through major theorems/run time analysis related to universal hashing. This randomized algorithm is, on average, a more efficient method to store data. The poster will also walk through methods of designing functions that are used to randomly hash data. Applications of this method can be seen in perfect hashing algorithms, cryptology, and data analysis.

Katelyn Gutteridge, Missouri Western State University
[B] *Mathematics in the Stock Market*

Is it possible to use Mathematics to forecast stock movement? Stock market prediction is an area that involves looking at past data to anticipate the future data and outcomes. By using iPython Notebook with real world data to look at the stock market we can attempt to predict short-term outcomes through the Monte Carlo method combined with different states of stocks.

Melanie Harrison, Lewis University
[B] *Image Thresholding in Python Using the Otsu Method*

Image thresholding allows a binary image to be created from an original image. This process turns the pixels on or off based on the gray-level of each pixel. One popular form of image thresholding is Otsu's Method. Otsu's Method relies on a bimodal histogram to transform a gray-scale image into a binary image. Furthermore, this method is a form of adaptive thresholding and maximizes the interclass variance of the pictures, separating the foreground and background pixels. This poster will show Otsu's Method and how this process can be applied in a programming language such as Python. The process of segmenting an image by defining a pixel as either light or dark (a zero or one) has many applications, not limited to computer science or mathematics. The use of image thresholding is prevalent in fields such as medicine and forensics. The purpose of this project is to explore image thresholding, and its possible applications.

Joni Hazelman, Northern Arizona University
Parker Montfort, Northern Arizona University
[B] *Explorations of Conway's Sylver Coinage Game*

Sylver Coinage is a game in which two players, A and B, alternately name positive integers that are not the sum of nonnegative multiples of previously named integers. The person who names 1 is the loser! This seemingly innocent looking game is the subject of one of John Conway's open problems with monetary rewards. One such open problem is: If player A names 16 to start, and both players play optimally thereafter, then who wins? In this talk, we will discuss a simplified version of the game in which a fixed positive integer n (greater than 2) is agreed upon in advance. Then A and B alternately name positive integers from the set $\{1, 2, \ldots, n\}$ that are not linear combinations with positive coefficients of previously named numbers. As in the original game, the person who is forced to name 1 is the loser. We will investigate who wins under optimal play for given values of n and determine the Nim-values for the simplified game under certain conditions.

Janolin Higgins, Missouri Western State University
[A] *Analysis of Crime Data in Kansas City, Missouri*

Using the programming language Python, we statistically analyzed and graphed crime data from Kansas City, Missouri. We used this analysis to determine main points of crime throughout KCMO. We studied how the main locations of crime in the city changed over the years, and predict future hotspots. We studied when crime was the highest during any given year. The data we used is over a 5 year span and only contains data from Kansas City, Missouri and not from surrounding Kansas City suburbs.

Emily Hoopes, Youngstown State University
[A] *Developing an Educational Sudoku Solver*

During the past year, we developed a Sudoku solving application that employs logical solving techniques to find the solution to a given Sudoku puzzle and then offer hints to the user to enable them to successfully complete the puzzle. Other Sudoku solver applications determine the correctness of a puzzle and determine the location of particular numbers, but do not advise the user which solving technique to use. Through logic, this application generates and solves puzzles while helping a user improve their Sudoku solving skills.

Megan Hudock, The University of Scranton
[B] *A Mathematical Model of Mechanical Injury to the Articular Cartilage of the Knee Joint*

Articular cartilage is a sophisticated living tissue that lines the surface of joints. Injuries to the articular cartilage typically occur as traumatic mechanical destruction or progressive mechanical degeneration. Since there is no direct blood supply to the cartilage, it is unlikely that it will completely repair itself. In this presentation, we describe some consequences of mechanical destruction of the articular cartilage in the knee via mathematical modeling with an aim to discovering the effectiveness of certain intervention therapies to improve injury response. From this model, we conclude the maximum force articular cartilage can withstand given the death rate of the chondrocytes, the rate of degradation of the extracellular matrix, and the rate of replenishment of the matrix and the type and the amount of treatment needed to restore cartilage given the aforementioned parameters. In addition, we have also determined the maximum force the cartilage can withstand upon re-injury following treatment.

Marisa Huffman, Pacific University
[A] *Optimizing Image Classification Methods using the SURF Feature Descriptor*

Image classification is the process of training an image classifier to recognize objects in images or to categorize images based on numerical data. The image classification method implemented was Speeded Up Robust Features, SURF, which identifies and describes points of local contrast. A linear support vector machine, SVM, was trained for image classification. Our data was obtained from Reddit, a forum where users vote on submissions. MATLAB was used for image analysis on nontraditional data. We also implemented nontraditional techniques, such as using a binary SVM model to predict whether image submissions would be successful ("good") or not ("bad") and the point score the image received. Classifying images by "subreddit" had a statistically higher level of success than other classification methods. The predicted score had no correlation to the actual success of the image. This suggests the users vote on submissions based on external factors, such as humor or text being present in the image.

Keynee Johnson, Stephen F. Austin State University
[A] *Reliability Polynomials of Simple Graphs having Arbitrarily Many Inflection Points*

An open question within the network reliability community is whether or not there are reliability polynomials of a graph with multiple inflection points. In a previous paper by Dr. David Milan and Dr. Christina Graves, it was proven that multigraphs have arbitrarily many inflection points. This poster will further investigate inflection points of simple graphs' reliability polynomials.

Madison Kellar, Colorado School of Mines
[A] *Cardiovascular Dynamics During Blood Withdrawal*

The body continuously regulates system properties to maintain blood pressure at homeostasis, preventing fainting or light-headedness during everyday activities. This project aims at understanding how system properties are controlled during blood withdrawal by utilizing a five-compartment mathematical model of systemic circulation to predict cardiovascular dynamics. The model is validated against experimental pressure and volume data measured in the hearts of rats, made available from collaborators at the University of Michigan and the Medical College of Wisconsin.The body's natural responses during blood withdrawal, such as increased heart rate and vasoconstriction, are represented by model parameters, and the objective of this project is to understand how these parameters change in time to predict experimental observations. Techniques used to estimate time-varying dynamics include piecewise linear splines and ensemble Kalman Filtering, the latter providing a measure of uncertainty in parameter estimates.

Carrie Kralovec, Colorado School of Mines
[A] see **Taylor Chott**

Betsy Langland, Lewis University
[B] *Determining the Success of a Mathematics Major*

Obtaining a Bachelor's degree in mathematics is difficult, and sometimes students drop this major after a few semesters. Thus, it would be beneficial to both the student and the advisor if it were possible to predict whether or not that student would succeed in finishing the major. In order to explore this idea, we did preliminary data analysis of de-identified transcripts and records from Lewis University mathematics majors over the past 10 years. As part of this research, we used cluster analysis and applied linear algebra to organize and find trends in the data. During this talk, we will discuss some of the surprising issues that we had to overcome along with our initial findings from the data analysis.

Mae Markowski, George Mason University
[B] *A Fractional Diffusion Model for Electric Signal Propagation in Cardiac Muscle Tissue*

It is well known that cardiac muscle tissue is inhomogeneous, but the accepted model used to describe electrical signal propagation in the tissue does not treat it as such. We propose a fractional space-time diffusion model, which will better account for the spatial complexity of the region.

Heather McCain, Schreiner University
[B] *Feynman Diagrams and Nonlinear Perturbed Systems*

Feynman diagrams are shown to be applicable to nonlinear systems described by perturbation theory or stochastic modeling. Developed to describe subatomic particle interaction, Feynman diagrams provide a geometric representation of the behavior of a nonlinear system with perturbations over time. The historical use of Feynman diagrams in physics is discussed, and some uses in nonlinear mathematics are described.

Parker Montfort, Northern Arizona University
[B] see **Joni Hazelman**

Melinda Moore, Washburn University
[B] *Correlations and Trends Between University Rankings and Salaries at Washburn University*

Study cross referencing ranking of Washburn with distributions of salaries across various categories for last 10 years. I will be presenting stats results of this study and all applicable correlations.

Theresa Morrison, San Diego State University
[B] *Shallow Waves in Density Stratified Bilinear Shear Currents*

In this poster we examine the role of nonlinearity on the evolution of surface and internal layers in density stratified fluids with steady but different shear currents in each stratified layer. Our work addresses two physically motivated parameter sets which display a range of nonlinear phenomena. We also show, when the difference between the vorticities in each layer is sufficiently large and of different signs, large amplitude nonlinear phenomena, particularly along the internal layer, emerges. Dispersive shock wave and solitary wave phenomena appear in the parameter regimes examined in this work. Our results show that jumps in density and vorticity generate strong nonlinear responses, and therefore sea state models should account for these variations in order to improve their predictive capabilities.

Mary Mulholland, Francis Marion University
[A] *Modeling the Dengue Virus*

This research focuses on modeling the dengue virus, a dangerous but still mysterious disease. The SIR model is used to mathematically describe the interactions between susceptible humans and mosquitoes along with their infected and recovered counterparts. Euler's method is implemented to simulate the spread of the dengue virus in both human and mosquito populations. Model results for human populations are be compared with data from recorded outbreaks of the dengue virus.

Brittany Myers, University of Central Oklahoma
[B] *Cellular Models of Canine Parvovirus*

Parvovirus is a virus that infects actively dividing cells in many animals, including dogs. Canine Parvovirus type 2 (CPV2) has two forms, intestinal and cardiac, which often kill young dogs when they become infected. We built differential equations models to better understand how CPV2 infects host cells. The model includes viruses, infected cells, target cells, protected cells, and antibodies. Since there are multiple ways antibodies inhibit infection, we built two different models to study the different types of antibody response. Based on our model results, we propose the most effective method for fighting off CPV2 after infection.

Carrie Narvaez, University of Montevallo
[B] *Complex Matrices and their Eigenvalues in the Complex Number*

A scalar, λ, is an eigenvalue of a matrix A in the complex number system if there exists a nonzero vector $\mathbf{x}$ such that $A \cdot \mathbf{x} = \lambda \cdot \mathbf{x}$. In this paper we will study the relationships between several complex matrices and their eigenvalues. Some of the types of matrices we will be studying include: hermitian, nilpotent, singular, idempotent, and more.

Annabel Offer, Texas Tech University
[A] *Mathematical Model for Time to Neuronal Apoptosis Due to Accrual of DNA DSBs*

We propose a mechanism to explain neuronal aging by tracking the number of non-transient DNA double-strand breaks (DSBs) and repairs over time that may lead to apoptosis. Neuronal apoptosis depends on the amount of space between DSBs as well as time. We derive three models to track the effect of neurodegeneration: a system of autonomous Ordinary Differential Equations (ODEs), a probability model to track the spatial requirement, and a stochastic model that incorporates both the ODE temporal dynamics and a spatial probability model. Using these models, we estimate a distribution for the lifespan of a neuron and explore the effect of parameters on time to death. We identify three possible causes of premature neuronal apoptosis: problems with coding critical repair proteins, issues with the neuron detecting DSBs, and issues with the neuron responding to DSBs.

Melida Paz, California State University Northridge
Miriam Ramirez, California State University Northridge
[A] *Modification of the Collatz Problem*

The Collatz Conjecture has remained an open problem to prove that for any positive integer the sequence formed by this integer will end in the limit cycle $(4; 2; 1)$. We investigate the map $T : \mathbb{N} \to \mathbb{N}$ defined by

$$T(x) = \begin{cases} \dfrac{x}{p} & \text{if } p \mid x \\ mx + r(x) & \text{if } p \nmid x \end{cases}$$

where $r(x)$ is such that $p \mid (mx + r(x))$ and $0 < r(x) < p$. For $m < p$ we have the following:

(i) for any positive integer x the sequence $x, T(x), T^2, \ldots$ will end up in a limit cycle,

(ii) if p divides x then $T(x) \leq x - 1$ and if p does not divide x then there exists a positive integer n such that if $x \geq n$ then $T^2(x) \leq x - 1$,

(iii) there are at most $p - 1$ limit cycles $c_1, c_2, ..., c_{p-1}$ for all positive integers p and m,

(iv) $\{x \in \mathbb{N} : x \to c_j\}$ is infinite for all limit cycles c_j.

We also investigate the special cases where $m = p - 1$.

Victoria Prawitz, Pacific University
[A] *One Rook, Two Rook, White Rook, Black Rook*

A rook polynomial is a generating function giving the number of ways to place r non-attacking rooks on a given board. Non-attacking rooks are when no two rooks share the same row or column, so these rooks could not attack each other in a real game of chess. Traditionally, the rooks are not distinguishable. We consider the case where the rooks were distinguishable. In particular, sets of rooks of two colors, where rooks of the same color can be in the same row or column and not be considered attacking. We explore the maximum number of distinguishable rooks can be placed on a given board, the number of ways to place non-attacking distinguishable rooks on a board, and expressing those values as a polynomial. Further investigation involves the uses and expansions on a rook polynomial for distinguishable rooks

Ellen Prochaska, Creighton University
[B] *The Role of Calcium in Metabolic Oscillations of Pancreatic Beta Cells*

Beta cells in the pancreas are responsible for the production and regulation of insulin based on changes in glucose levels. Ultimately, secretion occurs due to changes in the calcium concentration levels in beta cells. A mathematical model has been developed that captures the full dynamics of insulin secretion from electrical and glycolytic oscillations. Using the Dual Oscillator Model, we examine how calcium handling within individual pancreatic beta cells affects the synchronization of metabolic oscillations within electrically coupled islets. Calcium permeability was implemented into the Dual Oscillator Model. Numerical solutions of the system were obtained via Matlab using a modified ordinary differential equation solver for stiff systems and the Automatic Differentiation for Matlab software. We consider how calcium diffusion between cells affects the behavior of metabolic oscillations and their synchronization. Our research shows if calcium diffusion enhances or diminishes metabolic oscillations.

Miriam Ramirez, California State University, Northridge
[A] see **Melida Paz**

Esbeida Ramos, Pacific University
[B] *Complicating the Idea of Rook Polynomials*

A chromatic polynomial of a graph G counts the number of proper vertex colorings of G. List coloring restricts the colors available for each vertex to a specific set. A rook polynomial counts the number of ways to arrange k rooks onto an $m \times n$ board so that the rooks are non-attacking, meaning no two rooks share the same row or column. Both rook polynomials and list coloring help solve various real life applications and can get extremely complicated very quickly. We find a relationship between rook polynomials and list coloring. Also, I explore what happens when we try to find the rook polynomial of a three dimensional board, and even further, ask if we can generalize this formula for an n-dimensional board. Furthermore, what kinds of applications would it serve to be able to take some sort of product of two boards, and what would that look like? Finally, do these higher dimensional boards or board products relate back to list coloring?

Sherise Requiestas, California Lutheran University
[A] *Creating Sports League Schedules through Graph Theory*

This poster represents sports league schedules as graphs, marking the teams as vertices and the games as edges. I investigate the Edge Coloring Algorithm. It produces a single round robin tournament for an even number n teams. The research expands on it to work on an odd number of teams and adds directed edges, assigning Home and Away games. The goal is to have the least amount of breaks (2 consecutive Home or Away games for a team) and byes (team does not play a game in a round) because they are seen as undesirable. The project also creates an optimal schedule of what is considered fair between teams and meets the required criteria: all teams play each other twice and each team has the same number of breaks and byes. A proof is presented that for any round robin tournament with n teams, at least $n-2$ teams have breaks. The expanded algorithm's efficiency creates a double round robin tournament for n teams such that each team has no more than two breaks and is tested on my school's sports league schedules.

Maria Sanchez-Muniz, The City College of New York
[B] *Hausdorff Dimension of Limits Sets of Hyperbolic Groups Acting on the Upper Half Plane*

The research topic is Hausdorff dimension of limits sets of hyperbolic groups acting on the upper half plane. This involves the calculation of estimates of the Hausdorff dimension of limits sets of hyperbolic groups acting on the upper half plane. It is really a geometric topology problem related to solutions of the PDE known as Laplace's equation on the surface which is the quotient of the Poincare upper half plane by the hyperbolic group. The limit set is a Cantor set. This Hausdorff dimension is related to the lowest eigenvalue of the Laplacian acting on the surface, and ultimately this problem is related to the famous Riemann hypothesis.

Monika Satkauskas, Creighton University
[B] *A Host-Parasite-Commensal Ecological Model Based on Field Studies in the Great Plains*

Although mathematical models for ecosystem dynamics exist, most do not consider commensal relationships found in the niche. We offer a model for a freshwater snail-trematode-Chaetogaster ecosystem found at the Pine Ridge Indian Reservation. Trematodes infect the snails, while the Chaetogasters both prey on the trematode larvae and have a commensal relationship with the snail. We analyze populations in terms of a nonlinear host-parasite-commensal ecosystem model using the Hartman-Grobman Theorem to find stable equilibria, and for more involved eigenvalue computations, we give intervals that guarantee asymptotic stability via the Routh-Hurwitz Theorem. Additionally, we plot the percent of snails (in- and out-of-transect) infected with Chaetogasters against the observed trematode infections, and a linear regression shows Chaetogaster prevalence correlates negatively with trematode prevalence.

Kallie Simpson, Slippery Rock University
[A] see **Kristina Bell**

Melissa Stadt, University of Washington
Catherine Sullivan, Siena College
[A] *Detecting Gene-Gene Interactions that Underlie Cancer using the R Package Algstat*
Interactions between single nucleotide polymorphisms (SNPs) and complex diseases have been an important topic in epidemiological studies. Previous genome-wide-association studies have mostly focused on gene variables at a single locus. In our project, we perform a focused candidate gene study to test the interaction of multiple SNPs with the risk of different types of cancer. Using the R package algstat, developed by Kahle, Garcia-Puente, and Yoshida, we developed an algorithm which can test for independence between several variables and the disease. We applied our methods to the study of gene-gene interaction on cancer data. We were able to find strong evidence to reject independence of many triplet combinations of SNPs with the disease. These results are relevant to the general field of epidemiology due to the strong association found between the variables and the disease. Outside of the study of SNP-cancer association, this algorithm can be easily adjusted to be used in many research areas.

Catherine Sullivan, Siena College
[A] see **Melissa Stadt**

Kristina Sundy, University of Central Oklahoma
[A] *Modeling the Interaction between Rothschild Giraffes and Acacia Trees*

Rothschild giraffes are on the verge of extinction, so many are kept in conservatory enclosures. While in enclosures, giraffes face threats and hardship, including their food supply. This project provides a solution to this problem. We create mathematical models of the relationship between acacia trees and the Rothschild giraffe. We analyze the biology of each of these species and how they affect each other in a conservation enclosure. While in enclosures, giraffes have a limited quantity of acacia trees available, resulting in over-browsing and debarking of acacia trees. Acacia trees adapted to the amount of browsing done by giraffes by increasing tannin production to keep the giraffes from over-browsing. We develop a predator-prey model to study the interaction between giraffes and acacia trees as well as a model of how the tannin levels of the acacia tree affect the health of the giraffe. We use these models to help conservationists with the health and wellness of the Rothschild giraffe species.

Alyssa Tomlinson, Loyola Marymount University
[A] *Pre-service Teachers' Development of Questioning Skills through Common Core*

This study documents the effects of video observation on the development of deep questioning skills of pre-service teachers in a mathematical content course for K-8 pre-service teachers. In particular, we examine the questioning strategies used by pre-service teachers in written responses related to Common Core aligned videotaped math lessons.

Bianca Verlangieri, Colorado School of Mines
[A] *Mathematically Modeling Tumor Growth using Chemostat Model*

It has been shown in previous research that an effective way to model the growth of a tumor undergoing continuous infusion chemotherapy is by using a chemostat model. In this model the tumor is restricted to the liver and it is assumed that all tumor cells are equally exposed to the drug. This previous model was nondimensionalized and analyzed through finding steady states and their stability. However, to make this model more realistic, the assumption that all tumor cells were equally exposed to the drug was eliminated. The findings of this new model represent a more realistic situation in treating the growth of tumors using continuous infusion.

Aleina Wachtel, Harvey Mudd College
[A] *Geometric Realizations of Sparse Neural Codes*

It is vital to study how neural codes store information to gain a better understanding of the brain. The combinatorial information in a neural code can allow us to determine if the code reflects the firing behavior of neurons with convex receptive fields. We seek to determine which neural codes can be realized as convex open sets in $\mathbb{R}^2$. We restrict to codes showing sparse behavior, specifically codes in which no more than 2 neurons fire simultaneously, to reduce the intractability of determining which neural codes can be so realized. Using geometric properties of neural realizations, we find necessary and sufficient conditions for realizability of 2-sparse codes based on the associated co-firing graph. This yields a complete characterization of which 2-sparse codes can be realized in $\mathbb{R}^3$, and characterizes the realizability of several classes of codes in $\mathbb{R}^2$. With this characterization, we can better comprehend the manner in which biologically viable codes are spatially represented in the brain.

Yingying Wang, University of California, Santa Barbara
[B] *p-adic L-functions and p-adic Class Number Formula*

In this talk, I would like to introduce p-adic L-functions, which are analogues for Dirichlet L-functions. I will give an outline of the construction/proof of the p-adic version of Class Number Formula.

Gabriella Warrensford, Stetson University
[A] *A Model of Nutrient Flow in an Aquaponics System using Diffusion-Advection-Reaction Equations*

Aquaponics is a combination of hydroponics (growing plants in a soilless environment) and aquaculture (raising fish in a tank). As a byproduct of respiration, fish excrete toxic ammonia from their gills. In an aquaponics system, the water in the fish tank is pumped to beds where plants are grown in a soilless medium. Nitrifying bacteria colonize in the medium, and convert ammonia to nitrite and then nitrate. The plants can readily absorb the nitrate as a vital nutrient, and the water, which is now free of the toxic ammonia and nitrite, is pumped back to the fish tank. We will attempt to simulate nutrient flow in an aquaponics system with a two-dimensional model. For each of the three substances of interest: ammonia, nitrite, and nitrate; a diffusion-advection-reaction equation will be used to determine its concentration within the fish tank and plant bed as a function of time and space. Model parameters will be estimated based on empirical evidence,and possible solution techniques will be discussed.

Michole Washington, Georgia Institute of Technology
[B] *Arithmetic Properties of Infinite Products*

The work discussed here develops methods to evaluate certain infinite products in closed-form. These are infinite products of values of the gamma function. Presented here are infinite products of rational functions $R(n)$ raised to the power of some sequence M_n. The sequences satisfy certain regularity conditions as either a l-periodic or k-automatic. Of particular interest is the regular paperfolding sequence considered by J.P. Allouche.

Hannah Willenbrink, Cedarville University
[B] *OR in Airline Fleet Assignment*

My poster demonstrates using operations research to minimize costs in airline fleet assignment. Operations research applies linear algebra to an optimization problem creating a linear program, consisting of a set of variables that make an objective function and a list of constraints. A Fleet Assignment Model assigns a fleet to each flight. The variables represent flight legs by fleet and are assigned operations costs. Multiplying these variables by respective costs gets our objective. Constraints are numerous but come in five main forms: Cover constraints maintain each flight is only assigned one fleet type. Balance constraints ensure the number of flights taking off at a given time doesn't exceed the number available. Count constraints ensure the number of planes of a fleet in use and on the ground never exceeds the number available. Value constraints determine the type of number, binomial or integer, assigned to each variable. I also give examples of implementations used to adjust the program.

Adela Yang, Bowdoin College
[A] *Text-Mining and Topic Modeling the Wall Street Journal to Find Market Inefficiencies*

In this project, we aim to find semi-strong form inefficiencies in the market and delays in stock price changes following the release of publicly available information online. Specifically, we analyze all publicly available articles on the online archives of The Wall Street Journal. We make predictions about stock behavior following a day by assuming it will be similar to days when similar news are published online. In order to analyze text, we implement Natural Language Processing (NLP) to refine our text documents and Latent Semantic Indexing (LSI) to group words into topics and analyze the frequency these topics appear in a given day. Then, we make predictions about the behavior of the stock market under the assumption that its behavior will mimic days when there is a similar frequency distribution of these topics.

Sarah Yoseph, Loyola Marymount University
[A] *Double Interval Circular Societies*

Klawe, Nyman, Scott and Su considered linear societies where approval sets are double intervals, which are disjoint unions of two intervals. In our work, we consider double intervals on circular societies where the approval sets are arcs of equal length. Our research focuses on the minimum fraction of voters that will agree with each other in societies where the maximum number of intersecting sets is as small possible. We construct bounds that relate the diameter of these intervals to the number of double intervals, which we denote by n. This motivates the question of determining the minimal agreement proportion for pairwise intersecting approval sets, and we conjecture that as n increases, the agreement proportion approaches $\frac{1}{3}$.

Shih-Hua Yu, University of Southern California
[A] *Automated Plankton Classification*

Plankton, at the foundation of aquatic webs, plays a big role in our ocean ecosystems. By accurately measuring the distribution of various types of plankton, we will be able to determine present ocean health and to predict major changes in these ecosystems. Given a large set of images of plankton, our team developed an algorithm to classify plankton accurately and efficiently. To train our algorithm, our team implemented Random Forests, which involved developing an ensemble of decision trees that used classification and regression analysis to reduce bias. In addition, we used Convolutional Neural Networks, which involved using linear filters on our input images and then applying activation functions to create multiple feature maps that helped sort the plankton into the various classes. We will discuss the specifics of our implementations and our results.