Abstracts of Student Talks
Mathematical Association of America
Allegheny Mountain Section Meeting
Edinboro University of Pennsylvania
Friday, April 9, 2021

7:00 - 7:15 p.m.

Emily Shuttleworth, Geneva College, Room 1
Eigenvalue Inclusion Sets
Eigenvalues are used in Linear Algebra and other math-related disciplines in characterizing matrices. Computers have the ability to solve for these eigenvalues directly, but are prone to errors when dealing with large matrices and matrices in which entries are complex. The eigenvalues that computers calculate may or may not be correct depending on whether or not the matrix is ill-conditioned. The purpose of my research was to investigate different methods of bounding eigenvalues.

Caleb Thompson, Penn State University, Room 2
Differential Modeling of COVID-19 Cases in the US
This project utilizes a modified form of the logistic growth differential model $P' = \alpha P(1 - P/M)$ to examine the spread of COVID-19 in various countries. The logistic growth model was modified by 1) replacing the capacity constant M with a time-dependent capacity function $m(t)$ and 2) rewriting the equation to state $P'' = \alpha P'(1{-}P'/m(t))$, meaning the model now represents new daily cases instead of total cases. All graphs were generated using Matlab and Euler's method for analyzing differential equations. These changes grant a massive amount of control over the model's behavior, allowing piecewise modifications at different times to fit the diverse behaviors of the virus over its various "waves" and phases. This project focuses primarily on the virus's behavior in the United States, but also discusses the behavior of the virus in the United Kingdom, Mexico, and Sweden, showing the flexibility of the model. Some possible interpretations are then presented based on the model's numerical results, as well as comparisons between the four countries analyzed. The possible interpretations presented are differing environments (both weather based and population-density based differences), differing mitigation measures, and differing testing practices. This project also deals in small part with the impact that vaccinations might have had on the recent behavior of viral spread, but since vaccine production at scale is a relatively recent occurrence, it is not the main focus. Ultimately, this project demonstrates the flexibility of differential equations for modeling population growth of COVID-19, as well as providing some insight into the behavior of the virus over in different countries.

Peter Kruse and William Daugherty-Miller, Juniata College, Room 3
Hospital Acquired Infections Classified by Neural Networks
To explore the construction and implementation of Convolutional Neural Networks (CNNs) in the context of eliminating Hospital Acquired Infections (HAIs). Our Network will utilize Stochastic Gradient Descent (SGD), non-linear ReLU functions, and backpropagation in order to measure the efficacy of AIONX cleanSURFACES Technology. This Neural Net will be coded in the statistical programming language R using the Tensorflow and Keras machine learning libraries. The results from this project will create a reproducible CNN program that can be applied to a variety of microbial data.

7:20 - 7:35 p.m.

Dionna Pearce and Drew Cramer, Geneva College, Room 1
Disease Spread Math Model
The purpose of this project is to continue to develop a mathematical disease spread model as well as find values for the parameters in the model. This model considers not only the usual variables in a disease spread model but also the effects of vaccinations. This model consists of a system of ordinary differential equations.

Christina Pospisil, U.S.A., Room 2
Generalization Theory of Linear Algebra III
The talk continues the presentations Generalization Theory of Linear Algebra I+II from JMM 2019 and JMM 2020. In the first part an algorithm for multiplying matrices regardless of dimensions via an embedding and inverses for non-injective mappings in one dimension were presented (first part was presented at JMM 2019). The second part presented inverses for non-injective mappings in one and multiple dimensions and introduced a general determinant theory (second part was presented at JMM 2020). The third part is dedicated to a further generalization regarding tensors with first applications in physics. In future work there will be further operations and applications to physics and other natural sciences be explored. JMM = Joint Mathematics Meeting

Sydney Shearer, Juniata College, Room 3
A Mixed-Method Approach to Investigating Difficulty in Data Science Education
The purpose of this study was to investigate student difficulty in data science classrooms and identify common disconnects in understanding between data science students and their instructors. A mixed-method approach analyzed open response survey data from students, faculty/instructors, and teaching assistants across three institutions. Our research design combined qualitative content analysis with the statistical text-mining technique of term frequency inverse document frequency analysis. We present our methods and preliminary results on pilot data to provide direction for multi-disciplinary research teams seeking new or alternative approaches to analyzing large text-based datasets in educational research.

Chris Catullo, Julia Foust, Giaco Gentile, Henry Gise, Connor Horan, Jacob Kefalos, Hugh McMurray, Nate Palmer, Aaron Reuter, Troy Reinhardt, and Jiyue (Tom) Yang, University of Pittsburgh, Room 4
Optimizing Defensive Alignments in Major League Baseball
The use of data analytics, specifically Sabermetrics, has been prevalent in Major League Baseball (MLB) since the mid 1900s. Paradigms such as The Shift, the strategic realignment of the defending team from traditional positioning, have risen to popularity as pragmatic and effective strategies to reduce runs conceded. Given a set of MLB batting data, including about 200,000 data points, our aim was to determine an optimal defensive alignment against each player and create an associated visualization. We will present our exploration of Optimization and Machine Learning techniques to reach a practical solution to this problem statement.

7:40 - 7:55 p.m.

Rebecca Luketic, Fairmont State University, Room 2
Discrete Legendre Polynomials
In this presentation, we will discuss a discrete version of the Legendre polynomials. An important part of this will be the use of falling powers instead of the common monomial powers. This will include how we changed the normal recurrence relations along with other functions. We will also look at generating functions for these discrete Legendre polynomials.

Kazuki Makino, Juniata College, Room 3
Numerical Range Over Finite Fields
The numerical range of A is defined as $W(A) = \{< Av, v >:< v, v >= 1\}$. We investigate the numerical range of a matrix over the finite field $Z_7[i]$. Previously, the relationship between numerical range of a matrix over $Z_7[i]$ and the boundary generating curve was investigated. Since the result was shown only for a special type of matrix, it is our purpose here to investigate the relation between the numerical field and the boundary generating curve more broadly.

Sammy Alali, Brendon Gu, Dexter Harrell, Josh Howe, Max Synder, and Juliette Wong, University of Pittsburgh, Room 4
Predicting Post-Peak MLB Player Performance Per Position
In this project, we assess the ability of a Major League Baseball position player to play each defensive position. We also explore methods to predict future defensive performance, as measured by the components of defensive runs saved (DRS). In particular, position-specific and player-specific aging curves, and a similarity metric for players based on the Mahalanobis distance are used to draw accurate player comparisons using defensive statistics. These are used as inputs for a system that predicts future defensive performance for an individual player at each position. Subsequent considerations include weighted multi-year projections and predicting future position changes.

8:00 - 8:15 p.m.

Dallas Freeman, Fairmont State University, Room 2

Discrete Polylogarithms

The polylogarithm is a special function of which a special case includes the famous Riemann zeta function, and it has applications to quantum statistics and mechanics. There has been recent interest in discrete analogues of special functions, and considering the discrete analogue of the polylogarithm has led us to some interesting results. In this talk, we will define these functions, examine their similarity to the traditional polylogarithm, and consider some results that stem from their hypergeometric representations.

Joshua Gottlieb, Seton Hill University, Room 3

Computer Graphics - A Synthesis of Subjects

Computer generated images (CGI) are an essential part of modern entertainment. Mere decades ago, CGI was in its infancy and was instantly recognizable due to its low quality. Now, it has become indecipherable from real images to the naked eye. As a society, we take CGI for granted, but what actually goes into creating images on a computer?

This paper seeks to answer this question in a manner understandable to the average layperson and mathematician. To properly understand the methodology of the modern renderer, we briefly survey techniques and concepts from the fields of art, biology, psychology, and physics. Then, a rudimentary ray tracing model is introduced, and its shortcomings are discussed. Monte Carlo Integration is detailed as a method of suitably sampling a complex scene using a finite number of rays based off of probabilistic techniques. Connections between mathematical concepts that appear in an undergraduate curriculum and mathematics in computer graphics are briefly considered.

Katie Brosky, Santhosh Donepudi, Josh Howe, and Max Snyder, University of Pittsburgh, Room 4

Trends in Natural Gas Production: Big Data and Decline Curve Analysis

In this presentation, we discuss our work for an energy company looking to predict trends in energy production. Using 700,00 data points obtained from DEP.PA.gov, we seek to predict well locations and the success of future wells through decline curve analysis. Visuals of our progress will be presented and we will offer our new analysis of these curves and how this compares with historical methods used in the industry.