The Thirteenth Annual Nebraska Conference for Undergraduate Women in Mathematics

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POSTER ABSTRACTS

Posters by Undergraduate Students

Genevieve Becicka, University of Northern Iowa
Equivalent Representations of Standard Young Tableaux

Standard Young tableaux are diagrams used to study the symmetric and general linear groups. I investigate an observed possible relation between groups of standard Young tableaux. This has led me to explore various equivalent representations of the tableaux, including the triangulation of polygons and matched parentheses. The most contributive representation in understanding the observed relation between the tableaux has been multidimensional lattice paths.

Elisabeth Berg, Seattle Pacific University
Chord Recognition Through Wavelet Decomposition

Wavelet decomposition can be utilized in a variety of applications, including the analysis of chord frequencies. This poster shows research done involving the comparison of guitar chords using wavelet decomposition, including the creation of a MATLAB program to identify chords.

Margaret Bonfardin, Washington University in St. Louis
A Tale of Four Flowers

Clustering is the act of partitioning a set of elements into subsets, so that elements in the same cluster are, in some sense, similar. Determining an appropriate number of clusters in a data set is an important issue in data mining and cluster analysis. Another important issue is visualizing the strength of clusters. We begin by creating a consensus matrix using multiple runs of the clustering algorithm k-means. This consensus matrix can be interpreted as a graph, which we cluster using a spectral clustering method. To determine if increasing the number of clusters from k to $k+1$ is appropriate, we check whether an existing cluster can be split. We also present our method for visualizing the strength of clusters by using the consensus matrix and the clustering obtained through one of the spectral clustering techniques. Using these methods, we then investigate Fisher's Iris data set. Our methods support the existence of four clusters, instead of the generally accepted three clusters in this data.

Elizabeth Braha, Seattle University
Playing with Knots

This presentation will be focused towards introducing and gaining some understanding of the basic concepts associated with the branch of mathematics called knot theory. The hope is to learn some basic intuition about the nature of knots through a game involving a three-coloring on torus knots. Through some discussion of game theory and its application to a knot game that we have produced, this presentation will delve into some of our primary results involved in creating a winning strategy, and our hopes for future results.

Elizabeth Connelly, Furman University
A Note on Gamma Graphs

As introduced in the paper by Fricke, et. al., given a graph $G = (V; E)$, the gamma-graph $G(\gamma) = (V(\gamma); E(\gamma))$ is the graph whose vertex set corresponds 1- to -1 with the gamma-sets, or minimum- cardinality dominating sets, of G. Two gamma-sets, say S_1 and S_2, are adjacent in $E(\gamma)$ if there exists a vertex v in S_1 and a vertex w in S_2 such that v is adjacent to w and $S_1 = S_2 - \{w\} \cup \{v\}$ or equivalently, $S_2 = S_1 - \{v\} \cup \{w\}$. In this paper we investigate two open questions regarding these gamma-graphs. First, we consider whether every graph H is the gamma-graph of some graph G, and we show that for every graph H, there exists a graph G such that $G(\gamma)$ is isometric to H. Second, we investigate when $G(\gamma)$ is disconnected. We prove that all graphs of order $n = 5$ have connected gamma-graphs, and we determine all graphs G on six vertices for which $G(\gamma)$ is disconnected.

Samantha Corvino, Slippery Rock University
Comparing Site Differences from the PORT Pneumonia Study

In 1991, the pneumonia Patients Outcomes Research Team (PORT) began a three year cohort study to identify and understand the medical outcomes of CAP (Community-Acquired Pneumonia) across five different sites. To compare the differences between inpatient and outpatient care, the hospital admissions process was based on demographic considerations, vital signs, and comorbid condition variables. This presentation will utilize several chi-square tests and nonparametric tests to compare the differences in these variables among the five sites. This research is a byproduct of the SIBS Pittsburgh Program and the funding of the NIH.

Mauntell Ford, University of Kansas
Biologically-Based Lumping of a Quaternary Fuel Mixture

Biologically-based lumping methodology (BBLM) developed at the EPA provides an effective way to efficiently analyze large systems of chemicals. Chemicals are lumped together into pseudochemicals to reduce the number of total chemicals in the biological system of interest. This process decreases the number of differential equations, which represent the behavior of chemicals in the compartments of the body involved in the system. The formation of BBLM is based on metabolic terms: the Michaelis constants for enzymatic reaction and the maximum enzymatic reaction rate. Each chemical within the lump is weighted equally. Error is calculated based on a comparison of the lumped and unlumped chemicals. We have applied BBLM to a set of four chemicals, which shows that the system may be reduced to one chemical. The error found during exposure within the lump was .3005% for ethylbenzene and .5262% for m-xylene. Error after exposure in ethylbenzene was 1.1174% and 1.4315% in m-xylene.

Sabrina Gonzales, Adams State College
Rithmomachia

Rithmomachia is an old number game. It is a very complex game with multiple objectives. I am finding strategies for the more simple objective using abstract algebra and game theory. For the more complex objectives, I am finding the combination of game pieces that will allow a player to win.

Katie Groskreutz, Minnesota State University, Mankato
Classification of Childhood Cancer Subtypes from Microarray Data

Neruroblastoma, rhabdomyosarcoma, non-Hodgkin lymphoma, and the Ewing family of tumors are four subtypes of childhood cancers. Each year more than 65,000 children are affected by these cancerous tumors. Symptoms may vary and are often fatal. Therefore, it is essential that these cancers are correctly diagnosed and classified because of different treatment options. However, these four cancers are often difficult to distinguish between and accurately identify by normal methods of diagnosis. A microarray analysis distinguishes between the cancers by determining which set of genes are active in an organism. The purpose of this research is to determine a series of statistical methods that can most accurately identify the type of cancer for each patient based on the information from the microarray data. Then, the method will be applied to new patients to accurately diagnose them. The methods being explored in this research project include SCOOP, PAM, and other clustering methods such as k-means and hierarchical.

Rose Hamershock, Muhlenberg College
Dynamics of AND-NOT Boolean Networks

Boolean networks are powerful tools in studying complex systems and lend particular aid to the study of gene regulatory networks. The state space of a Boolean network is of special interest because it describes the behavior of the gene system. In particular, steady states are of great importance as they correspond to the final fate of biological processes. Hence, the development of mathematical tools is key in understanding these systems that are commonly governed by the AND, OR, and NOT operators. In this presentation we demonstrate that any Boolean network can be written as an AND-NOT network. We studied the dynamics of tree AND-NOT networks and the effect of feed forward loops on the dynamics of AND-NOT networks.

Kelly Hauser, Newman University
Whitney Poell, Newman University
Tiling Dissection and Quilting

Mathematics is not the first thing that most people would think of when discussing quilting. This "relaxation method" actually is a very complex form of combining geometric figures. It mainly concerns the construction of shape, size, and position of each figure used. We were mostly concerned with the idea of creating shapes that would be able to fit together perfectly without any gaps. Through the incorporation of symmetry groups, including frieze groups and wallpaper patterns, we are able to explain the creation of a faultless quilt. We will demonstrate the process by which a pattern can be dissected through its translations, reflections, symmetries, and rotations. We will also discuss their inherent isomorphic properties and provide sufficient examples from both modern and historically known quilting patterns.

Cassy Jens, University of Wisconsin-La Crosse
Survivability Models of an Outbreak of Zombiism

Mathematical modeling of epidemics has grown increasingly important in recent years. Such models can predict how quickly a disease will spread through a population. The typical model used to describe the spread of an epidemic is the SIR model. This model uses a linear mass-action transmission, which assumes the transmission of the disease is proportional to the density of susceptible and infected populations. In their 2009 paper, Smith, et. al. used SIR models to study the spread of a zombie epidemic through a population. Their models show that the only stable equilibria result in the human population decreasing to zero. We show that by considering a nonlinear mass-action transmission, stable equilibria solutions exist for which the zombie population decreases to zero. The nonlinearity in the mass action transmission can account for differences in the populations. Through a bifurcation analysis, we were able to determine when human survival is possible in the models.

Heather Johnston, Western Oregon University
Chord Recognition Through Wavelet Decomposition

Many factories use signal analysis as a warning system for machine malfunctions. This is related to the problem of identifying different notes and chords. Our poster discuss this signal analysis problem and how it can be treated through wavelet decomposition. We will present an algorithm that identifies guitar chords.

Kelsy Kinderknecht, University of Kansas
Keatra Nesbitt, University of Northern Colorado
The Elusive Rank 9: Finding Curves of High Rank

The concept of ranks of elliptic curves is not well understood; in fact, we do not know how large the rank of any given elliptic curve over $\mathbb{Q}$ may be, so we try to find curves of high rank to better understand this concept. The elliptic curve $E : y^2 = (1 - x^2)(1 - k^2x^2)$ for some rational $k \neq -1, 0, 1$ has torsion subgroup $E(\mathbb{Q})_{tors} \simeq Z_2 \times Z_4$ when $\sqrt{1 - k^2} \notin \mathbb{Q}$. The highest known rank for such a curve is 8; we search for a curve of rank 9 or higher. To do this, we develop an algorithm to first generate a list of rational k and then to analyze these k's to find the rank of the curve.

Vianey Leos, California State University, Bakersfield
Stabilizing Generalized Cross-Validation for Smoothing Parameter Estimation

An important aspect of non-parametric regression lies in selecting a smoothing parameter to control the flexibility of a curve estimate. Generalized cross-validation (GCV) is a common data-driven method for automatically selecting a smoothing parameter; however, there are times when GCV will select a smoothing parameter that leads to an undersmoothed fit. Inflating the degrees of freedom of GCV by a constant multiplier has been shown to resolve undersmoothing, although no automatic method has been suggested for choosing the amount of inflation. Using the frobenius norm squared of the smoother matrix and the bootstrap, I will discuss a method of detecting when GCV selects a smoothing parameter that leads to an undersmoothed fit and selecting an appropriate amount of inflation.

Katie Linkchorst, Adams State College
What are you drinking?

A statistical analysis of water quality data in the San Luis Valley.

Anna Macquarie, Colorado State University
An Exploration of Topological Surfaces

Certain mathematical objects, such as the Möbius strip and the Klein bottle, have become recognizable symbols in areas outside of mathematics, such as art, literature, and magic. This expository project is an exploration of the mathematics behind some of these familiar objects. These objects can be described as topological surfaces, so this project involves a description of some fundamental topological concepts, and a close look at the classification theorem for compact surfaces.

Annmarie McGonagle, SUNY Plattsburgh
Ford Circles

Lester Ford introduced Ford circles in 1938 in order to understand, geometrically, the approximation of an irrational number by rational numbers. We shall construct the Ford circles by a recursive geometric procedure. The Ford circles also turn out to be parameterized by the rational numbers (i.e., for any rational number a/b in lowest terms, we can construct a circle with center and radius determined by the numbers a and b). The fact that the two constructions are the same allows us to explain Ford's Diophantine approximation result. We introduce a new parameterization of the set of Ford circles in terms of triples of relatively prime integers that satisfy a certain equation. This is of interest since it seems to generalize to higher dimensions.

Rachel Meier, Colorado State University
Image Classification (Using Geometric, Linear Algebraic and Statistical Methods)

While the human brain has a remarkable capacity to recognize images, there is proven success in utilizing computers to help classify images, however, much remains to be done. This project explores methods of categorizing the information in a set of digital images through analysis of the information contained in the corresponding array of real values representing an image. Several data sets of digital images were collected and invariants were attached using geometric, linear algebraic and statistical tools. A new data set of query images was introduced and subjected to a series of comparisons each of which received a weighted "vote ultimately used to decide which data set the query set was most similar to. Further methods are currently being explored to in order classify digital images with increasingly more subtle differences.

Samantha Monastra, Cabrini College
Putting Lights on a Christmas Tree

The holiday of Christmas comes around once a year and people merrily string lights about their Christmas trees. However, the rows of lights may be unevenly spaced and not as aesthetically pleasing as if the rows of lights were evenly spaced. There is a way for determining the vertical spacing between each row of lights such that the rows are evenly spaced and begin at the top of the tree and end at the bottom of the tree. In this presentation, given a tree's height h and radius r, and the length of a string of lights L, the vertical spacing d will be determined.

Keatra Nesbitt, University of Northern Colorado
see **Kelsy Kinderknecht**

Liem Nguyen, University of Wisconsin at Oshkosh
Parity of k-regular partition functions

A k-regular partition of a positive integer n is a partition of n whose parts are not divisible by k, and we denote $b_k(n)$ as the number of k-regular partitions of n. We are interested in the parity of these functions, in particular the exact criteria for when $b_k(n)$ is even. In this presentation, we will prove such criteria for the parity of $b_7(n)$ and $b_{13}(n)$ and show that these functions satisfy Ramanujan type congruences modulo 2.

Haema Nilakanta, Iowa State University
A Particle Based Model for Cell Movement

In this paper, we use the particle method to simulate a cell. The cell is represented as a group of sub-elements, which maintain fixed and equal volumes in three dimensional space. We run simulations by applying appropriate forces to each particle. We tested the capabilities and limitations of this model to see if was a realistic representation of a cell. In implementation, we calibrated the model so that the cell preserves volume and we included random noise, force cutoffs, and an efficient implementation. We were able to simulate a single cell as an equilibrated sphere, adhere the cell to a plate, make the cell move, and elongate the cell. The ability of the particle method to simulate a moving cell is the best demonstration of its capabilities. Future extensions of this model would enable further testing of the particle method.

Stephanie Oh, Northwestern University
Visualization of the family of expander graphs, $SL2(q)$ with various generating sets.

A family of expanders is a family of networks with a bound on the size of the connections, which is increasing in size and difficult to disconnect. The study of such graphs are useful for understanding networks that require high connectivity but have limited resources. A construction of one family of expanders uses the Cayley graph of $SL_2(q)$ with various generators. The construction gives us a non-constructive proof that both the diameter and the girth grow with the logarithm of the size of the graph. We explore better visualizations of expander graphs, other than through algebraic constructions and bounds on various properties of the graphs. In order to gain an intuitive understanding of general families of expanders, we search for different ways to characterize the graph using only graph theoretical notions.

Arpita Patel, Furman University
Renewal Systems

Renewal systems and shifts of finite type are two types of symbolic dynamical systems. Although defined differently, both are edge shifts and it is not known whether or not every shift of finite type can be represented as a renewal system. Roy Adler first asked this question which has motivated much research, including this one. Both shift spaces and shifts of finite type have a special function associated with them, called the zeta function. If two different shifts have common representations, then they have the same zeta function. In this presentation we give appropriate definitions and compute the zeta functions for some classes of renewal systems.

Whitney Poell, Newman University
see **Kelly Hauser**

Heather Ranney, Newman University
The Secrets of TimeA Study of Cryptography throughout History

Keeping information private has been a major issue in todays society with the new advances in technology. With more people putting important private information on the internet, there is a greater need for data encryption. One popular type of encryption includes the RSA method, which is a type of cryptography involving modular arithmetic. This project will describe the history of cryptography and the mathematics behind it. Flowing from the Caesar Cipher to RSA encryption, different methods will be explored and modeled. Also, this project will demonstrate the connections between ancient cryptography and modern encryption.

Jordan Rooklyn, University of Montana
Matroids, Fixing Sets and Maker-Breaker Games

Maker-breaker games are two-person games in which the first person, Maker, tries to create a winning set while the second player, Breaker, tries to stop Maker. This game has been applied to matroids and graphs with various types of winning sets. We examine the game played on matroids in which Maker is trying to create a fixing set. A fixing set S of a matroid is a subset of the ground set so that the only automorphism of the matroid that fixes S pointwise is the identity. For example, fixing three noncollinear points of the Fano matroid, the matroid linked with $PG(2,2)$, fixes the entire system. In this poster, I present strategies and outcomes of such a game played on matroids associated with finite geometries.

Mary Russell, Canisius College
Log-linear ODEs and Applications to the Ricci Flow for Homogeneous Spaces

The Ricci flow is a geometric evolution that tries to evenly distribute the Ricci curvature throughout the manifold. On a homogeneous space, one can consider the bracket flow, an analog of the Ricci flow that evolves the structure constants of the Lie algebra. We analyzed a class of ODE arising from the bracket flow on nilpotent and solvable Lie algebras. For two dimensional systems, we completely classified the possible geometric behavior. In all dimensions, we found sufficient conditions for collapsing, and necessary and sufficient conditions for the existence of soliton metrics.

Sharee Russell, University of Montana
Maker Breaker Games and Fixing Sets

A Maker-Breaker game is a game played by two players, Maker and Breaker, on a system (E, F), where E is a finite set and F is a collection of subsets of X. Players alternately choose elements of E. Maker tries to create an element of F while Breaker tries to prevent this. An example of such a game is the Shannon Switching game: X is the set of edges of a graph and F the set of paths between two distinguished vertices. Lehman generalized this game to matroids and solved the problem of who wins in 1964. In this poster, I will present results of a different type of Maker-Breaker game. The game is played on a matroid M in which E is the set of elements of M and F is the collection of fixing sets of M. A fixing set S of the matroid M is a subset of E such that the only automorphism of the matroid that fixes S element-wise is the identity. I will explore which types of matroids are always maker wins, breaker wins, or neutral (first player wins) and the strategies therein.

Lauren Slocum, The College at Brockport, State University of New York
The First Prime After a Long String of Composite Numbers

It is well known that one can generate a string of consecutive composite numbers as long as one wishes. For example, if we want to find 100 consecutive numbers, none of them prime, we look at $101!+2, 101!+3, 101!+4$, and so on, up to $101!+101$. We can also look at $101!-2, 101!-3, 101!-4$, and so on, down to $101!-101$. Eventually, though, if we keep going we will reach a prime number. If $k > 1$ and $n!+k$ is prime then obviously k has no prime factors less than n. The Indian mathematician Murthy conjectured that the first occurrence of a prime after $n!+n$ always happens when a prime number (greater than n) is added to $n!$ We analyzed the density of occurrences of $n!+k$ to be prime when k is prime, or the square of a prime or a product of two prime numbers. We also looked at the case when the numbers are subtracted from $n!$ and the case in which $n!$ is replaced by the product of all prime numbers less than or equal to n.

Hannah Stanton, University of Montana
Maker Breaker Games

"Maker-Breaker" games are two player games typically played on graphs. The object of Maker-Breaker games is for Maker to create a basis on the graph while Breaker tries to prevent this from happening. A game with a winning strategy is one that, independent of playing order, maker always wins; a neutral game occurs when Maker must go first to win; and in a losing strategy, Maker always loses. Following this background, we examined the Shannon Switching game. This game varies a bit from the original Maker-Breaker game. We then decided to analyze Maker-Breaker games creating bicircular basis on bicircular matroids instead of graphic matroids. We looked at what generalities translated directly and which needed additional qualifications to hold.

Brittney Turner, Baylor University
On a Class of Totally Unimodular Matrices

This poster will demonstrate when a certain class of $0, \pm 1$ matrices is totally unimodular (TU). Through the use of Eulerian submatrices, the task of determining total unimodularity is significantly simplified. Also, the Kronecker product of two TU matrices is used to form larger TU matrices, an occurrence that is not true in the general case.

Rebecca Waldrip, Furman University
The Fast-Food Diet Problem

In 1945, economist George J. Stigler published "The Cost of Subsistence", where he determined the minimum-cost diet meeting basic nutritional guidelines for an average man. The diet consisted of foods that could be purchased at supermarkets and prepared at home. Today, Americans dine out frequently. As the percentage of Americans that dine out regularly increases, concerns over healthcare costs and obesity have risen, leading individuals to become increasingly concerned with nutritional diets. Here, we consider the fast-food diet problem. We attempt to determine a minimum-cost diet satisfying nutritional constraints and comprised of foods that can be purchased at fast food restaurants.

Katie Watkins, Sam Houston State University
The Magic Behind Franklin Magic Circles

Dr. Benjamin Franklin is popularly known for his creation of the lightning rod, bifocals, and many discoveries regarding electricity. He also participated in the fundamental foundations of the United States of America including co-writing the Declaration of Independence. To avoid weariness in congressional debates, Franklin used his intellect to create both magic squares and magic circles. Franklin Magic Circles are whole numbers arranged in concentric circles such that when added in specic patterns the sum will be the same. In our presentation, we will discuss the recreation, enumeration, and symmetry operations of Franklins original magic circle, as well as a new, unique Franklin Magic Circle. We will use algebraic techniques to unravel the mysteries of Franklins creation while revealing the fascinating characteristics that dene Franklin Magic Circles.