Abstracts of Student Talks

Mathematical Association of America
Allegheny Mountain Section Meeting
Westminster College, Friday April 4th, 2014

7:35-7:50 PM

Jenna Huston, Westminster College, Patterson 105

Neural Network Hidden Layer Size

Artificial neural networks (ANN) are computational models inspired by the brain. This talk will give a brief overview of ANNs including how networks learn through weight changing schemes and details about network configuration. Determining the optimal number of nodes in the hidden layer(s) of an ANN is a very difficult problem. Rules of thumb have been determined, but there is not an exact way to decide this. We seek to find the optimal hidden layer size of a data set by simulating training ANNs with 2-7 nodes in the hidden layer to a mean squared error of 0.01 and 0.1. We then eliminate some of the training data and use it as test data to test the network for overtraining. We find the optimal hidden layer size is 3 nodes when using a mean squared error of 0.01 or 0.1. We also found a correlation between very large and very small connection weight values for networks that did not train to the desired mean squared error and got stuck at the same mean squared error.

Yukihide Nakada & Douglas Nestor, Allegheny College, Patterson 107

Normal Weighted Composition Operators on the Dirichlet Space

We characterize the normal weighted composition operators $W_{\psi,\varphi}$ on the Dirichlet space $\mathcal{D}$ in the case when φ is a linear-fractional self-map of the unit disk $\mathbb{D}$ with fixed point $p \in \mathbb{D}$ and ψ is bounded and analytic on $\mathbb{D}$. In the Hardy space and Bergman space, it is known that $W_{\psi,\varphi}$ is normal precisely when

$$\psi = c\frac{K_p}{K_p \circ \varphi},$$

with $|c| = 1$ and $\varphi = \eta\alpha_p$ with $|\eta| = 1$, where K_p is the reproducing kernel and $\alpha_p(z) = (p - z)/(1 - \overline{p}z)$. We show that no nontrivial normal weighted composition operators exist on the Dirichlet space; that is, $W_{\psi,\varphi}$ is normal on $\mathcal{D}$ if and only if ψ is constant and $\varphi(z) = cz$, where $|c| \leq 1$. We also extend some of these results to weighted Dirichlet spaces.

Jonathan Cohen, Duquesne University, Patterson 205

Wavelets and Beyond: Mathematical Models of Image Noise

Removing noise from images is one of the most important tasks in image processing, as it is often a required first step before getting useful information from the picture. Because of this, it's very important to develop accurate mathematical models of noise to use when trying to get rid of it. Recently, a time and frequency domain technique using linear algebra, called "wavelets," has proven to be a very good model distinguishing noise from image content. Specifically, wavelets can be used to define sets of functions called "Besov spaces" which consist of piecewise smooth images with edges, similar to what you would see from natural pictures. Wavelet-based methods, however, introduce "gridding" artifacts due to location invariance. We show how to represent Besov Spaces using finite differences and introduce a denoising method based on this alternate definition.

Shane Whitacre, Slippery Rock University, Patterson 207
The Life and Legacy of Hypatia

The field of mathematics historically does not call for major recognition of some of its greatest contributors. Compared to other fields where names such as Beethoven, Darwin, and Freud are popular names that the common colligate has no problem recalling, mathematics does not call for similar recognition. Lets expand this argument to include women in mathematics as well. With the common educated person barely having any knowledge at all on some of the most famous male mathematicians, one can expect that the knowledge on female mathematicians can be considered little to none. One can argue that these women deserve even more recognition not just for their contributions to the field of mathematics, but also for breaking through the stereotypes and discriminations that existed during the time periods that each of these women lived. One of the first significant and well-known female mathematicians was Hypatia. Although her life is seen as a popular Greek tragedy, Hypatias' achievements as a mathematician and as a scholar are generally overlooked.

Krista Munger, Gannon University, Patterson 208
Dominating Multidimensional Chess

The domination number of a chessboard for a particular piece is the fewest number of pieces needed so that all spaces on the board are either occupied or can be attacked by at least one of the pieces. The independence number of a chessboard for a particular piece is the maximum number of pieces that can be placed on the board such that no two pieces can attack each other. I consider questions of domination and independence for a two-dimensional triangular board and a three-dimensional triangular board on the surface of a tetrahedron. Domination and independence numbers for many of these pieces on these boards of different shapes and sizes are found.

7:55-8:10 PM

Lola Lesi, Juniata College, Patterson 105
Dieception: Die within a Die

We will be testing the fairness of a 20 sided die within a 20 sided die. Unlike loaded and weighted dice which are biased to specific faces of the dice and unfair, there is uncertainty as to whether a die within a die is fair. The die could be unfair because it is know that the drilled numbers on the die faces affect the fairness of dice. Another reason for the uncertainty is because the inner die is not fixed but rather rolls on the inside, constantly changing the center of gravity of the outer die. Also, the inner die is constrained by the outer die and has a limited space to move which could affect the fairness of the inner die. To conduct this analysis, we collected data from a 1,000 die rolls and we will test our data for randomness and fairness using tests such as the frequency, runs, and serial tests.

Greg Adams, Penn State Erie, The Behrend College, Patterson 107
Misconceptions About Limits Held by Beginning Calculus Students

The limit concept is a fundamental and crucial one that is found throughout all levels of calculus. It is an abstract concept that can be difficult to fully understand from a student's perspective, and it can also be difficult to teach. People in mathematics know that the meaning of the term "limit" in calculus is quite different from other meanings of limits in everyday life such as a speed limit or weight limit. Even having encountered the term in different ways can make students view calculus limits in incorrect ways. This research has significance both from a pure mathematical standpoint as well as from an educational standpoint. My study will detail the most prominent limit misconceptions, how they might be acquired, and how the teaching of limits plays a part in these misconceptions.

Natalie Hilbert, California University of Pennsylvania, Patterson 205
Fibonacci Infusion

In this talk, I discuss the solution to an open problem submitted to the journal "The Fibonacci Quarterly." To begin, I discuss the Fibonacci sequence and its importance in nature. Then, at first glance at the conjecture, it seems that there are two distinct inequalities that need to be proved individually. However, a more general route can be taken to prove both halves at the same time. Being that I prove two inequalities using a more general fact, I plan to create "Fibonacci Infusion."

Matthew Morrow, Indiana University of Pennsylvania, Patterson 207
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Do you like to solve puzzles? Do you like writing secret messages? Do you want to figure out how to decode this title? In this talk we will discuss the math and history of classical encryption and decryption techniques.

Jackie Yanchuck, Seton Hill University, Patterson 208
What Can I Do with a Mathematics Major?

If you are a math-loving nerd with no idea what your degree would be good for, suffice it to say you've come to the right place. This question is asked so very often, and the answer to it is scary: Anything. You. Want. Truly - your skills you gain as a mathematics major make you so marketable, you could work in a large variety of fields. This also makes it very hard to figure out what you'd like to do in the future. For my Honors Capstone project, I created a website to help other undergraduate mathematics majors who are grappling with this question that I grappled with throughout my undergraduate career.

8:15-8:30 PM

Noam Berns & Katie Dalzell, University of Pittsburgh at Johnstown, Patterson 105
Do You Want To Improve Your GPA?

This statistical research project looked at the many relevant and irrelevant factors affecting the grade point average of college students. The results from our sample of 140 students will be discussed.

Greg Clark, Westminster College, Patterson 107
A Push in the Right Direction: Proving the Density of Complement Sets

Given two sets of integers, A and T, we define the operation of set addition to be $A + T = \{a + t : a \in A, t \in T\}$. Suppose that A is finite in size and T is constructed such that $A+T = \mathbb{Z}$. In this talk, we will explore the relationship between A and the density of T. In particular, we will present a new proof technique for proving the density of T for a fixed A.

Samuel Miller, West Liberty University, Patterson 205
Examining Function Orderings Over Various Intervals

Functions normally cannot be compared with respect to size. However, the outputs can be directly compared. This project is an examination of some questions that arise when this idea is employed, specifically for polynomials.

Claire Saunders, Duquesne University, Patterson 207
Image Fusion Using the Calculus of Variations

A challenging problem in photography is taking pictures under difficult lighting conditions. For example, in dark and high dynamic range environments, the use of flash creates false color and shadows. One solution is to take a sequence of images in rapid succession using different exposure times. Long exposure images retain color information but lose geometric details. On the other hand, short exposure images retain fine detail but also contain noise and lose color information. In this talk we present a variational model for fusing a short and long exposure time image into a single output which retains the optimal information from each one. We derive how the model reduces to solving a partial differential equation and show some numerical results.

Julie Smicinski, Mercyhurst University, Patterson 208
Felonies and Mathdemeanors: Some Math Behind Solving Crime

Some popular TV shows and movies portray mathematics as a useful tool in forecasting crime. Can crime analysts really improve their predictions utilizing mathematics? As part of an intelligence studies project, mathematical concepts and intelligence analysis techniques were blended to project the date and location of the next occurrence of a serial crime, as well as to profile the attacker. The conclusion of this talk will compare actual case findings to mathematical predictions.

8:35-8:50 PM

Colin Soleim, Allegheny College, Patterson 105
Introduction to Automated Theorem Proving using Propositional Logic and Resolution

Automating intelligence and reasoning has been a goal of human beings for the greater part of a century. This fantasy moved into the realm of possibility in the 1950s after the invention of the computer. Building off the work of logicians such as Lowenheim, Skolem, and Herbrand, mathematicians began to study the use of computers for automated theorem proving. This talk is an overview of the basics of automated theorem proving in propositional logic. It begins with a formalization of mathematical arguments using propositions, then studies the resolution technique of deduction, and finally examines the Davis-Putnam algorithm for proving the validity of an argument. We conclude with an overview of several automated theorem proving success stories and some current topics in the field.

John Wayland, Margo MacKenzie, Gayan Warahena Liyanage, & Scott Rega, Indiana University of Pennsylvania, Patterson 107
Preliminary Report: Mars Rover Optimal Path Determination

In 2012, NASAs Mars Exploration Program sent Curiosity, a 2,000 pound technologically innovative rover, on an approximately 354 million mile journey to Mars. Curiositys main mission is to study the "habitability" of Mars in an attempt to determine whether the planet has or has ever had an environment capable of sustaining any life forms. In the midst of this mission stand many obstacles. One of these obstacles is the determination of the best and safest paths for the rover to travel. These safety issues include changes in elevation, width of the path, uncertainty of the Martian terrain properties, and possible obstructions that may be present in the rover's path. In choosing the rover's path, all safety concerns must be appropriately considered. In this presentation, we will show our current model to aid in the determination of the safest paths, discuss possible extensions, and demonstrate a basic example using an aerial image and a corresponding topographical map.

Joe Petrone, Gannon University, Patterson 205
Dominating Honeycombs: Not Just for Bees

I calculate the domination number of a modified queen on tetrahedral honeycomb boards. I provide background information about hexagonal chessboards and the movement of the redefined queen on the 2-dimensional and 3-dimensional boards. I present results along with proofs for boards of small sizes and offer a wealth of open problems.

Reuben Jarrell, Edinboro University of Pennsylvania, Patterson 207
A Locally Euclidean Space Need Not be Hausdorff

In topology, there are several properties that are preserved by homeomorphisms. One such property is being a Hausdorff space. Any Euclidean space is also a Hausdorff space. This work will show that a space which is locally homeomorphic to a Euclidean Space does not need to be Hausdorff.

Jacob Clancy & Benjamin Tilley, Penn State Erie, The Behrend College, Patterson 208
Circle Packing within a Regular Polygon

Given a regular polygon containing an incircle each corner has space for another incircle tangent to the first and touching two of the polygon's sides. This process can be continued to get a series of circles packed within the polygon. In this situation we are trying to find the relationship between the number of sides of the polygon and the ratio going from the first incircle to the second.

8:55-9:10 PM

Michael Kubicek, California University of PA, Patterson 107
Where's Fibonacci?

In this talk I will discuss the solution to an open problem submitted to the journal "The Fibonacci Quarterly." We used the Fibonacci sequence along with Mahler's and the AM–GM inequality to prove the conjecture. Although it might seem tough at first, using these inequalities made it easier. You can find Fibonacci in this proof, that is why it is called "Wheres Fibonacci?"

Amy Ankney, Juniata College, Patterson 205
The Structural Analysis of Small Social Networks at Juniata College

Actor oriented social networks are a type of sociological analysis of the structure of friendship networks and how they change over time. This type of social network analysis was applied to students in two small majors at Juniata to observe what contributes to the presence and strength of friendships. The variables included were major, gender, and year, which have been collected by surveying Art and Math students at Juniata. They will be analyzed to conclude how the variables affect their friendship networks, enjoyment of classes, and overall enjoyment of major. We are looking to observe if people who enjoy their majors are more likely to be friends with people who enjoy their own. The data was statistically analyzed to quantify the influence of each variable on the structure of the social network. The results will conclude what affects social networks in small majors at Juniata. Also it will show how one's friendship network affects their attitude about their classes/area of study and vice-versa. The social networks are expected to be based strongly on gender and major. This is a preliminary presentation on the social structure of the networks, because only one wave of surveying has been completed.

Connor MacKenzie, Westminster College, Patterson 207
Applying Topological Concepts of Geographic Information Systems to the Digital Plane

Applying the concept of intersection values to the digital plane and examining the consequences of this can produce some interesting results. This research will produce a method to help construct closed sets, and a partial characterization of the closed sets in the digital plane will be provided. Many results in the digital plane will mirror those of Franzosa and Egenhofer; however, the digital plane will help to add some clarity. The relationships that correspond to each intersection value will be examined under different restrictions on the sets under consideration.

Casey Hansen, Washington & Jefferson College, Patterson 208
Phun with Physics

In this talk I investigate solutions to the problem "Phun with Physics," in which a jar of 100 balls of 3 colors: red, yellow, and blue is shaken, and as balls collide they merge and change color. Based on given rules of collision, I am searching for the color of the final ball after 99 collisions. After solving this problem, I observe the problem under different initial conditions, and find that a solution can be found using concepts of group theory. I then proceed to search for applications of group theory in physics, and consider further possible applications.