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POSTER ABSTRACTS

Allison Beckwith, Saint Mary's College of California

Stochastic Innovation as a Mechanism for the Evolution of Scale-free Chemical Networks

The network representations of many biochemical processes and structure have been found to exhibit a scale-free topology. The existence of this topology has led to questions of how and why it may have formed; specifically, it is of interest to explore possible biochemical mechanisms that may have stochastically led to the evolution of scale-free biochemical networks. One mechanism by which these networks may have formed is by biochemical agents joining based on shared resources. This mechanism alone is not effective in creating scale-free networks, but it is sufficient to create networks exhibiting some properties of (and with the potential to become) scale-free networks.

Jahnavi Bhaskar, University of Chicago

Sum of Two Squares

I will investigate which numbers can be written as the sum of two squares and in how many ways, drawing on facts about number theory and the ring of Gaussian integers. Results regarding the sum of four squares and Waring's problem will also be presented.

Allison Blink, Purdue University Calumet

A Differential Equations Model of the Development of Viral Resistance to Anti-retroviral Drugs under Variable Treatment Regimens

This research project involves modeling the dynamics of Human Immunodeficiency Virus in the presence of drug therapy. After investigating the biological background of this problem, the evolution of different species concentrations will be examined using several mathematical techniques. We will begin with a simple system of equations and progress to a more involved one that includes both drug-resistant and wild strains of the virus. Finally, we will develop and analyze a mathematical model that investigates the effectiveness of anti-retroviral drugs in fighting HIV to show that antiretroviral drugs can lose their effectiveness when treatment schedules are not adhered to rigorously.

Eleanor Brush, University of Chicago

Three Theorems in Knot Theory

I will discuss basic definitions in knot theory, as well as give examples of the important ideas. Then I will present three important theorems in basic knot theory, and move on to give illustrations of the content of the theorems as well as their application.

Marlana Carrington, Miles College

Analyzing Winning Strategies of a 2-Player NIM for Alternating First Player

Nim is a challenging, multi-player mathematical game based on the removal of objects. The game has gained worldwide popularity as civilizations developed different versions and their concepts. For instance, Harvard University math professor Charles L. Bouden established the theory for the classic Nim game in 1901. In most Nim games, players alternate turns, selecting from multiple heaps (rows) of objects. However, in this study, we will observe a Nim game where two players select from a single row of flags in a serpentine direction; in other words, player 1 (P1) makes the first selection, then player 2 (P2) begins the serpentine rotation with two turns; afterwards, P1 does the same and so forth, and this pattern continues until no sticks are left. Additionally, we will implement a new mathematical concept to evaluate and confirm possible strategies for each player in surviving the game.

Whitney Coyle, Murray State University
Aileen Gaudinez, Chapman University

Statistical Analysis of Diffusion Tensor Imaging Data from Traumatic Brain Injury Patients

Diffusion Tensor Imaging (DTI) is a new tool used by researchers to non-invasively track changes in white matter pathways or connective fibers in the brain. After a traumatic brain injury (TBI) the connective fibers of the brain can become twisted, fractured or broken. The DTI is able to pick up white matter damage, which could cause developmental issues and delays, damage that may not have been found in a routine MRI. The two measures that the DTI can track are fraction anisotropy (FA) and the apparent diffusion coefficient (ADC). Here, we investigate the relationship between FA and ADC for traumatic brain injury patients as well as orthopedic injury (OI) patients. We use multivariate linear regressions on the data set to investigate the correlation between the two measures throughout different regions of the brain while account for type of injury, age, and gender.

Rebecca Dorff, Brigham Young University

Minimizing the Perimeter

We combined two problems, the Steiner point problem and the isoperimetric problem, to create a new minimization problem. The Steiner problem consists of finding the shortest network between a given number of points, and the isoperimetric problem maximizes area for a given curve. Using a new method developed by Dr. Gary Lawlor, called Metacalibration, we developed a proof for the combined problems to find the minimal length network that connects four points on a unit circle and encloses a given area.

Ellen Durant, Texas Tech University

Evening the Odds: Preconditioning Linear Systems

Numerical linear algebra is at the heart of scientific computing. In large-scale simulations, it often accounts for more than 80% of computational time. For large, sparse problems, iterative methods are essential, and preconditioning is key to iterative solver performance. Although a number of general-purpose preconditioners perform well for certain classes of problems, they struggle on other important classes, especially in parallel. We investigate preconditioners for linear systems arising out of a highly nonlinear circuit simulation in Xyce. Xyce is a high performance electrical modeling and simulation code developed at Sandia National Labs. These systems tax the performance of standard preconditioners.

Talia Erskine, Miles College

Reinforcement Learning

The Internet is ushering in a new era in computing. Where programming would be based on describing our preferences to software agents and let agents do the programming. The pleasant surprise is that for many problems, once we know the preferences, we're almost done! Given the preferences, a list of possible actions, and enough time to practice taking actions, we can apply the formalism of Reinforcement Learning (or RL) to build an agent that acts according to the preferences in a near-optimal way. This research will look at this formalism, its mathematical basis and the computation, and present one such way to build such agents.

Karleigh Frederick, Sam Houston State University
Samantha Hilker, Sam Houston State University
Katrina Lee, Sam Houston State University
Megan Savage, Sam Houston State University

Conway and the Knot Factory

Knot theory is a branch of topology investigating embeddings of the circle into $\mathbb{R}^3$. In the summer of 2008, we conducted an overview of knot theory including an investigation of: Brunnian links of arbitrarily many components, p-colorability including various methods for discovering appropriate moduli for colorings, and additive and multiplicative Conway notation with several procedures for determining if a random string of numbers will lead to a knot or a link.

Aileen Gaudinez
see Whitney Coyle

Samantha Hilker
see Karleigh Frederick

Annchen Knodt, Texas A&M University
Algorithm for Identification of Cancer-damaged Nuclei in Colon Crypts

Biologists often have the need to analyze large numbers of similar images in their research. Doing so by hand can be an extremely tedious and time-consuming job. Thus the need arises for an automated way to perform such tasks. Here we present an algorithm for locating and quantifying cancer-damaged nuclei in images from stained colon crypt microscope slides. We first present a simple statistical algorithm and its implementation as simulated in R. We then discuss our on-going work of the algorithm's implementation with CellProfiler, an image analysis software package in which we create modules to solve our particular problem.

Katrina Lee
see Karleigh Frederick

Kaylee Linthicum, Seattle Pacific University
Large-Scale Linear Programming: Survivable Network Design

The poster will give a brief introduction to to linear programming and the Simplex method. Survivable network design will be given as an example of a large-scale linear programming program. Heuristic algorithms that can be used to solve this problem will be presented and analyzed.

Jessica Olsen, University of Puget Sound
Flexagons

A mobius band with three half-twists shortened until it must be folded forms the trihexaflexagon, which behaves much like a cyclic version of a cootie catcher. The addition of half-twists leads to an intricate structure in the cycle map of the flexagon. Focus is on the relationship between the length of the strip forming the flexagon, and the corresponding cycle map.

Marlene Ouayoro, George Mason University
Set Partitioning Using Rectangles

Given a set in the plane that is the union of finitely many possibly overlapping rectangles each having sides parallel to the coordinate axes, the problem is to find a method to determine a representation of the set as a union of as few as possible rectangles, no two of which overlap. The computer scientist has a computer program that contains a procedure to process such sets, and the procedure works exceptionally quickly when the set is a rectangle. The idea is to partition the given set into as few rectangles as possible, and have the procedure process each rectangular piece. In order to be useful, our algorithm for producing the partition into non overlapping rectangles must work very efficiently, using very little computer time. This problem lies in the general area of combinatorial optimization. It is a special case of a set partitioning problem. There are methods for dealing with such problems in general. Often such methods make use of integer programming techniques. We will study techniques of linear and integer programming, with particular attention to set partitioning problems in particular, to learn about the algorithms for solving such problems.

Brooke Phillips, Murray State University
Lauren Schmidt, Murray State University

The Mathematics of Indian Drums

We will discuss the mathematics of Indian drums with a focus on the tabla and mridangam. These drums have evolved over many centuries and are the only known drums with harmonic properties, making them in some sense 'ideal drums.' We will derive solutions of the wave equation modeling the vibration of these drums. We will formulate an optimal design problem for the mridangam drum in an attempt to determine if the historic ideal drum is mathematically optimal.

Sara Rimer, Central Michigan University

Frames: Surgeries, Dilation, and Robustness

Frames are redundant sets of vectors in a Hilbert Space. They are a nontrivial generalization of orthonormal bases, and share many nice properties with orthonormal bases. The added redundancy from additional vectors allows for reconstruction of lost data in data transfers. We have considered some of the properties of frames into higher dimensions, and robustness of frames. In particular, due to the straightforward nature of tight and Parseval frames, they are a main focus of our studies. In this poster, we will present the necessary background material and some new results.

Carolina Rosa, Kean University

FDA and Regulations Reguarding NDA Process

In order for a drug to be legally distributed in the US market it must go through a lengthy process that inquires a series of tests which are evaluated by different specialists. These tests continue even after the drug is approved and sold on the market. If FDA requirements are not met, the drug can be removed from the market. This research is intended to help make a foundation to later determine the probability that a new drug will be approved or that an existing drug will be removed from the market. It will explain the new drug application process and the requirements a drug needs to meet in order to pass the FDA's two main requirements; a drug must be safe and effective. My intentions also are to come across the responsibilities statistical studies have in the US department of Health and Human Services.

Megan Savage
see Karleigh Frederick

Lauren Schmidt
see Brooke Phillips

Amanda Sgroi, Duquesne University

Perceptually Adaptive Bilateral Filtering: An Image De-noising

Perceptually Adaptive Bilateral Denoising is a method for removing noise from image data. Bilateral filtering is an edge-preserving, non-local regularization method. The proposed work improves upon this technique with a new methodology for automatically determining input parameters based on human perception. Noise removal algorithms in image processing typically seek to minimize numerical error rather than perceptual qualities. This isn't ideal for handling images with both highly textured and smooth regions. Our goal is to locally vary the bilateral filter parameters as a function of the expected level of human visual perception. The parameters are learned from noisy data for which the ground truth is known. Daly's visual difference predictor is used to estimate the error perceived by the human visual system. Simultaneously, power maps measuring the high frequency components of the signal are also generated. The error from Daly's VDP is used in conjunction with these power maps to locally determine the most efficient parameters in a given region. The denoising result is more aggressive in smooth regions and does not over smooth textured regions. Experiment results demonstrate the proposed method yields cleaner results based on standard visual difference prediction.

Heather Thompson, University of Northern Colorado

Normal Form of the Skein Algebra

Building on Bullock and Przytycki's paper, Multiplicative Structure of Kauffman Bracket Skein Module Quantizations, we examine multiplication of simple closed curves lying on the punctured torus and converting words from the skein algebra into normal form. Additionally we speculate whether the Dehn twist automorphisms about each generator generates the entire automorphism group of the skein aglebra.

Florencia Tolentino, Kean University

Adaptive Design in Clinical Trials

New things have been discovered to the benefit of humans' life. Science and technology are making an advance every day. Today, the process of clinical trials and their development of new drugs became a controversial issue, because of the time and money it takes. Researchers have introduced Adaptive Design as an alternative methodology in clinical trials (CT) than can be used to develop better medicines. The purpose of Adaptive Design (AD) is to help researchers develop safe and efficient drugs. AD allows modifications during the critical clinical trials if there is a need to change course of the study. It is an efficient procedure that is useful to produce safe drugs at a low price in a short time. This clinical trial design is known as "flexible design" because of the modification it allows, or "statistical design" because of the statistical process it involves. The purpose of introducing AD is to inform how it can develop safe and efficient drugs for patients, who are suffering from a disease. This investigation tries to explain specifically what Adaptive Design is and how it works. However, this investigation will continue in the future; applying this clinical trial method in real data. In addition, the reason for being interested in this topic is to generate and increase the possibility of using AD as the alternative to develop better medicines in the process of clinical trials, and make a difference in the future of science.

Sara Townsend, Sam Houston State University

An Exploration of Cayley Graphs

We explore Cayley graphs in order to discover connections between linear algebra and graph theory. We investigate adjacency diagrams and contracted matrices of small order Cayley graphs to find relationships between their adjacency diagrams and their eigenvalues. Using computer programs, we compute the eigenvalues of both the contracted and adjacency matrices. Eigenvectors of the contracted matrix give eigenvectors of the adjacency matrix. This shows that the eigenvalues of the contracted matrix form a subset of the eigenvalues of the adjacency matrix of a Cayley graph. We hope to use an association scheme to prove equality.

Sara Voss, Coe College

Performance of Graph Isomorphism Algorithms

Graphs are a powerful tool in pattern matching. A significant number of graph isomorphism algorithms are presented in literature but few papers characterize their performance. Consequently, it is not known how the algorithms are affected by the type, size, and node numbering variations presented in real world applications. A benchmarking activity for five general graph isomorphism algorithms, which aim to be practical solutions to the problem, is presented. Highly structured graphs ranging from a few nodes up to 16,000 nodes will be considered. The affect of the node numbering on graphs is also explored.

Staci White, Shawnee State University

4-Covering Maps on Elliptic Curves with Torsion Subgroup $\mathbb{Z}_2 \times \mathbb{Z}_8$

We consider elliptic curves over $\mathbb{Q}$ with the torsion subgroup $\mathbb{Z}_2 \times \mathbb{Z}_8$. In particular, we discuss how to determine the rank of the curve $E : y2 = (1 - x^2)(1 - k^2x^2)$, where $k = (t^4 - 6t^2 + 1)/(t^2 + 1)^2$ and $t = 9/296$. We use a 4-covering map $\hat{C}'_{d_2} \to \hat{C}_{d_2} \to E$ in terms of homogeneous spaces for $d_2 \in \{-1.6477590, 2, 7, 37\}$. We provide a method to show that the Mordell-Weil group is $E(\mathbb{Q}) \simeq Z_2 \times Z_8 \times \mathbb{Z}^3$, which would settle a conjecture of Flores-Jones-Rollick-Weigandt and Rathbun.

Jessi Yoakum, Metropolitan State College of Denver

Abstract Algebra and Geometric Constructions

Through the Greek's explorations they discovered that there were certain constructions that cannot be performed with a compass and an unmarked straightedge. One such construction is the duplication of the cube. An understanding of what numbers are constructible and the fields that these numbers create is needed and then one can recognize why it is impossible for one to construct the edge of a cube having twice the volume of a given cube with only these simple tools.

Kaitlyn Yoha, Duquesne University and University of Florida

Determining the Position of the Adiabatic Demagnetization Refrigerator and X-ray Detector in the Micro-X Sounding Rocket Payload

The Micro-X rocket is a small sounding rocket equipped with an X-ray telescope and will be launched in 2011. For the telescope to function properly, the adiabatic demagnetization refrigerator (ADR) must be aligned with the optics of the X-ray detectors. During the mission, the ADR will move, thus causing errors. A testing procedure and setup was designed and constructed in the lab to simulate the movement the ADR will experience in flight, and a program was created to analyze the data. This method will determine the orientation of the ADR relative to the detectors, and allow us to counter the resulting measurement errors.