Texas A&M Mathematics Department
REU/MCTP Summer Research Conference July 24-25, 2013
Presentations and Abstracts

Wednesday, July 24, 2013

10:20 - 10:40   *Estimating Amoebae of Polynomials Using Archimedean Tropical Varieties*
Eleanor Anthony, University of Mississippi
Research Mentor: Dr. J. Maurice Rojas

For a complex polynomial f, the amoeba of f is the image of the complex roots of f under the coordinate-wise log absolute value map. The Archimedean tropical variety has been proposed as a means of approximating the amoeba of f, and there is now an explicit bound on the Hausdorff distance between the two sets. We illustrate a polynomial time algorithm that computes the connected components of an ArchTrop for a given query point using linear programming methods. With this algorithm, we can approximate the nearest root of the polynomial using the Hausdorff distance bound.

10:45 - 11:05   *Algorithm for Estimating Amoebae of Polynomials Using Archimedean Tropical Varieties*
Sheridan Grant, Pomona College
Research Mentor: Dr. J. Maurice Rojas

We generalize our query-point algorithm for a single polynomial to many. While this yields an algorithm that is exponential in the number of variables, the algorithm also reduces the search space exponentially, allowing us to still approximate roots of polynomial systems efficiently. We will test our algorithm with the POSSO suite, a set of polynomial systems from well-known research papers or applications that are considered a standard for measuring an algorithm's effectiveness.

11:20 - 11:40   *Anderson Delocalization on the 3 Dimensional Lattice*
Westin King, Baylor University, Texas A&M University
Research Mentor: Dr. Constanze Liaw

In 1958, P. W. Anderson, who later won the Nobel Prize in Physics, conjectured that an electron could become trapped in some region of a semiconductor with sufficiently large impurities. This phenomenon is known as Anderson localization. While localization has been rigorously proven for disorder above some threshold, there have been no mathematically rigorous results concerning the random Schroedinger operator for weak disorder in dimension two and higher. Here we consider the problem in dimension three. The interest in our experiment is two-fold: it supports the widespread expectations of delocalization for small disorder, and it can be seen as verification of the numerical approach.

11:45 - 12:05   *Anderson Delocalization on the Honeycomb*
Amanda Hoisington, Baylor University , Texas A&M University
Research Mentor: Dr. Constanze Liaw

Recently developed numerical methods have been used to investigate the presence or absence of Anderson delocalization in two- and three-dimensional lattices. We explain the algorithm used in our approach and consider its implementation on more exotic geometries such as the hexagonal tessellation of the plane. The results obtained by these methods serve as verification of past conjecture and direction for a rigorous proof of delocalization for weak disorder in a variety of structures.

1:15 - 1:35   *What's the Word? Methods for Spoken Word Recognition*
Mac Edmondson, Emy Gaub, Celsey Lumbra, Ashley Orr, and Jessica Pereira
Research Mentors: Dr. Gregory Berkolaiko, Dr. Adam Larios

Our talk will present three different methods used for spoken word recognition; Haar Wavelet analysis, Discrete Fourier Transform, and Signal Analysis. We will reference five varying algorithms, each with a different method and basis for comparison. By comparing the data collected from executing our algorithms, we will share observations regarding which method correctly completes the spoken word recognition the most often and present conjectures on why this is occurring.

1:40 - 2:00   *Algorithms for Determining the Topology of Positive Zero Sets*
R. Joseph Rennie, Reed College
Research Mentors: Dr. J. Maurice Rojas, Ms. Kaitlyn Phillipson
We will present a quick overview of the front lines of Hilbert's 16th problem, as well as the various combinatorial, topological, and algebraic tools we aim to employ in the effort to prove that, given an honest, real n-variate $(n+2)$-nomial f, we can algorithmically determine the topology of the positive real zero set, $\mathbb{Z}_+(f)$ up to isotopy in polynomial time.

2:05 - 2:25   *Bounding the Number of Components of Positive Zero Sets*
Erika Refsland, Mills College
Research Mentors: Dr. J. Maurice Rojas, Ms. Kaitlyn Phillipson

Providing a brief background on Morse theory from differential topology and simplification methods from algebraic geometry, we present our proof of the following proposition: given an honest, real n-variate, $(n+2)$-nomial f, $\mathbb{Z}_+(f)$ has at most two connected components.

2:40 - 3:00   *I Whip my Haar Back and Forth: Constructing Algorithms for Letter Identification*
Daniel Mourad, Nicole Delphia, Josiah Oh, Jeremy Fus, and Rachel Ring
Research Mentors: Dr. Gregory Berkolaiko, Dr. Adam Larios

We examine various methods, such as Haar wavelet decomposition and the Fourier transform, for identifying hand-written cursive and Greek letters. We analyze which of these methods most accurately identifies the correct letter.

3:05 - 3:25   *Atherosclerosis: Modeling the Effects of Functional and Dysfunctional High Density Lipoproteins*
Kelly O'Bryant, Texas A&M University, Corpus Christi
Research Mentors: Dr. Jay Walton, Dr. Josef Sifuentes

Atherosclerosis details a complex set of detrimental biochemical processes within the medium- and large- sized arteries promoted by endothelium injury, cholesterol oxidation, and sinister immune responses. These interactions will be presented through a model containing eight coupled ordinary differential equations. Graphical techniques and asymptotic analysis will be employed to prove the existence and uniqueness of a uniform healthy state equilibrium in which all inflammatory markers become extinct with sufficiently high anti-oxidant concentrations.

3:30 - 3:50   *Modeling Lesion Growth in Atherosclerosis*
Kyle Thicke, Missouri S&T University
Research Mentors: Dr. Jay Walton, Dr. Josef Sifuentes

Atherosclerosis is the buildup of a fatty lesion in the wall of an artery. We numerically simulate a system of partial differential equations that models growth of lesions in an artery. Three separate models are investigated. We investigate the possibility of multiple equilibria. Numerical sensitivity analysis is done on some parameters to determine their effects on atherogenesis. We also investigate the positive and negative effects of HDL.

Thursday July 25

10:00 - 10:20   *Haarmony: Chord Recognition Using Wavelets*
A. Emmell, T. Reyes, E. Wheeler, K. Weber, C. Rodriguez
Research Mentors: Dr. Gregory Berkolaiko, Dr. Adam Larios

In this presentation we will be discussing the methods and algorithms we used to identify various chords. We will begin by briefly reviewing the topic of wavelets in relation to our research, then continue by explaining our methods of data collection, and our process for deriving our algorithm. In addition, we will discuss chord recognition using discrete Fourier transforms and raw data comparison. In conclusion, we will share our findings on the various comparisons and their efficiency in recognizing chords.

10:25 - 10:45   *Zeros of the Eisenstein Series of Weight 2*
Rachael Wood, Harding University
Research Mentors: Dr. Matthew Young, Dr. Sheng-Chi Liu

This summer, we have been looking at the zeros of the Eisenstein series of weight 2, which is a quasimodular form. It is known that the Eisenstein series has infinitely many zeros within the half-strip of the complex plane, however, apart from this fact not much is known about the location of these zeros. This talk will further investigate various properties of these zeros.

10:50 - 11:10   *Signature Authentication Using Wavelets and Fourier Analysis*
A. Singhal, J. Venzke, K. Pena, S. Coulson, B. Matys
Research Mentors: Dr. Gregory Berkolaiko, Dr. Adam Larios

This presentation discusses different ways of analyzing genuine signatures among forgeries using three methods: Fourier analysis, Wavelets and Original Data.

11:25 - 11:45   *Ecosystem Modeling With an Emphasis on Phytoplankton*
Danielle Rogers, Mississippi State University
Research Mentor: Dr. Jean Marie Linhart

Phytoplankton are small microorganisms that flow with the water current. Although they are small, their role in the ecosystem is important. If their interactions with each other and the environment are understood, that knowledge could be used to understand other organisms in similar ecosystems. Our research this summer was focused on studying the growth of phytoplankton communities. We looked at different nutrient interactions and models to see how the phytoplankton may react if they were to encounter these different nutrient levels. Our results showed situations in which one species out-competed the others and other situations which resulted in coexistence between the species.

11:50 - 12:10   *Modeling Phytoplankton Growth with Switching Nutrients and in Riverine Systems*
Hailey Bodiford, Blackburn College
Research Mentor: Dr. Jean Marie Linhart

Nutrient supply is thought to be one of the most limiting factors of phytoplankton growth. A switching nutrient model is applied to the phytoplankton growth model. The essential nutrient model is expanded to a riverine system and the rescue effect on biodiversity is explored as well. The effects of diffusion in the riverine model and how they limit biodiversity will also scrutinized.

1:15 - 1:35   *The Eisenstein Series and Related Topics in Number Theory*
Sam Dittmer, Brigham Young University
Research Mentor: Dr. Riad Masri, Dr. Matt Young

One important strategy in modern number theory is to study certain complex analytic functions whose behavior encodes number theoretic data. The classic example is the Riemann zeta function, whose zeros are intimately connected with the distribution of prime numbers. The real-analytic Eisenstein series plays a somewhat similar role. Its properties, zeros, and connection to Gauss's class number problem will be discussed.

1:40 - 2:00   *Nonvanishing of Class Group L-Functions*
Stephanie Seybert, Carnegie Mellon University
Research Mentor: Dr. Riad Masri

Class group L-functions, like the Riemann zeta function, are a current topic of intense study in analytic number theory due to their relation to the Riemann Hypothesis. In this talk, we discuss some fundamental ideas of analytic number theory along with new results on the existence of nonvanishing class group L-functions.

2:05 - 2:25   *On the History of Mathematics*
Michael Proulx, Harvard University
Research Mentor: Dr. Riad Masri

Our research draws upon a broad history of mathematical thought in number theory. We shall cover Cardano and the solution of the cubic, highlights from the 17th century, the creation of the calculus by Newton and Leibniz (and the subsequent priority dispute), and the work of the Bernoulli brothers. Later, we will examine Euler's various contributions to mathematics. Connections between these topics and our research will be discussed.

2:40 - 3:00   *From Quantum Chaos to the Riemann Zeta Function*
Xian Wu: Pomona College
Research Mentor: Dr. Matt Young

The Eisenstein series is a function with amazing symmetries. It appears in mathematical physics, specifically quantum chaos. The Eisenstein series also shares certain properties with the Riemann Zeta function, which is intimately connected with the distribution of prime numbers. The regions where the Eisenstein series is strictly positive or negative break the graph into nodal domains separated by nodal lines, the set where the Eisenstein series vanishes. We use Fourier analysis to prove that there are infinitely many nodal domains. We also present an algorithm to compute the number of nodal domains in a fixed compact set. In this presentation, we will show pictures of nodal domains and discuss their statistical properties.

3:05 - 3:25   *An Analysis of the Trojan Y-Chromosome Method of Invasive Species Management*

Jared Brown, St. Olaf College
Research Mentors: Dr. Jay Walton, Dr. Josef Sifuentes

Management of invasive species towards the goal of preserving native biodiversity and preventing economic damage has traditionally been one of the most challenging problems faced by modern ecological scientists. The introduction of modified members of the invasive species, carrying extra Trojan y-chromosomes, may offer a much less harmful, and thus less expensive technique for controlling or eliminating wild populations of undesired, sexually reproducing organisms. This paper presents both deterministic and Stochastic models of the reaction of the wild population to such Trojan introduction. Results upon arbitrary species parameters support the potential validity of this technique, and give insight into more environmentally specific interactions.