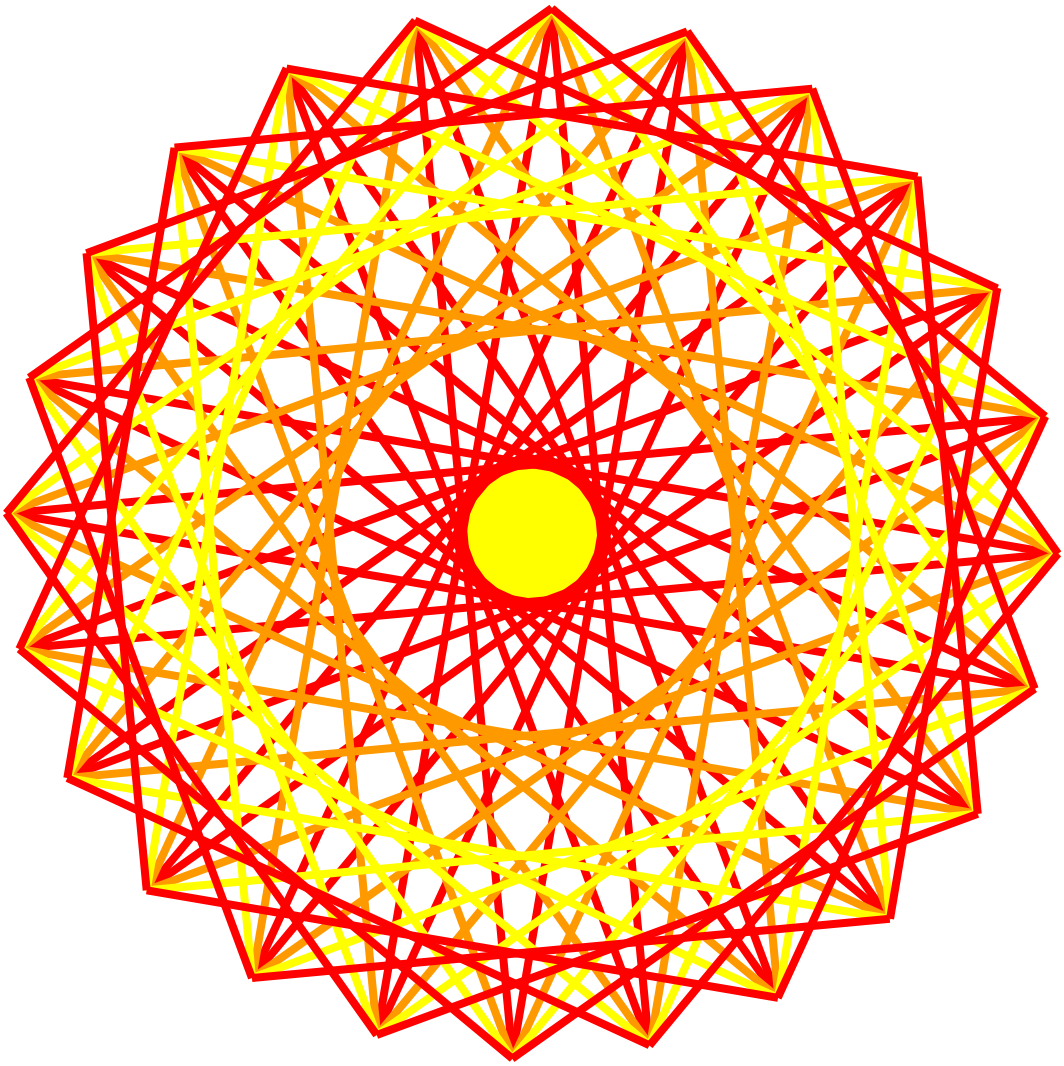
CAARMS15 Invited Speaker Abstracts



Fifteenth Conference for African American Researchers in the Mathematical Sciences
Rice University on June 23-26 of 2009

Nathaniel Dean
Texas State University-San Marcos

Data, Unsolved Problems, Computing and Incomprehensibility

nd17@txstate.edu

To understand interactions between entities (for example, people, objects or groups) systems of interactions are often modeled as *graphs* linking *nodes* (entities) with *edges* (representing various types of connections between the entities). After data collection there are many statistical approaches to analyzing the data. Our approach is to model data as a graph and explore the graph using a variety of tools such as optimization and visualization. In this talk we discuss ways to construct graphs from data, and we show how to use the graphs to reveal patterns. For example, we propose a metric that ranks groups based on their interactions with others. It applies to a variety of applications, its mean and variance can be computed quickly, and hence extremists (for example) can be identified in real time and the results used in interactive data analysis environments. Applications are numerous including social network analysis, counterterrorism, market basket analysis, epidemiology and molecular biology. The limitations of this approach are also discussed explaining why some graphs cannot be visualized and hence why certain data cannot be understood.

Jay Dweck
Morgan Stanley

The Role of Mathematics on Wall Street

Mr. Jay Dweck - Managing Director & Global Head of IDEAS (Innovative Environments Analytics & Systems) group at Morgan Stanley will highlight the use of Mathematics on Wall Street and how it plays an important part in the role of the Desk Strategist and Modelers. In addition, Mr. Dweck will give an overview of Morgan Stanley and a detailed account of the IDEAS group which encompasses all of Strategies, Modeling, Quantitative Research and Technology at Morgan Stanley.

Edray Herber Goins
Purdue University

Four-Covering Maps for Elliptic Curves

egoins@math.purdue.edu

There has been much interest in computing the Mordell-Weil groups of elliptic curves defined over the rational numbers. In 1963 and 1965, Bryan Birch and Peter Swinnerton-Dyer made extensive computations on the ranks of such elliptic curves, leading to surprising conjectures about the relationship with certain complex functions arising from Galois representations (namely the L-series) and certain groups arising from Galois cohomology (namely the Shafarevich-Tate group). In 1997, with the advent of stronger computing power and more efficient algorithms, John Cremona extended these computations.

The computational aspects of arithmetic algebraic geometry have expanded from simply computing special values of L-series to understanding how the ranks of elliptic curves are distributed. Many of these computations involve families of quadratic twists of elliptic curves. While this method helps to keep control over how fast the conductor grows, it does not keep track of how the torsion subgroup changes. Indeed, there is no extensive data at present on how the ranks of elliptic curves are distributed according to their torsion.

In this talk, we discuss ways to gain a better understanding of the ranks of those elliptic curves having as much torsion as possible. Many of the current methods in the literature used to compute the rank employ a descent via 2-isogeny. We outline new modifications by using 4-covering maps. Much of this work was done by undergraduates in the Summer Undergraduate Mathematical Sciences Research Institute (SUMSRI) at Miami University of Ohio.

Raquel Hill
Indiana University

Characterizing Trustworthy Behavior of Email Servers

ralhill@indiana.edu

The growth and wide-spread use of the Internet have led to the creation of more convenient services such as electronic mail or email communication. Email is one of the prevailing methods of communication and many organizations have invested heavily in building infrastructure to facilitate the availability of email. The abuse of email systems to send unsolicited messages, known as spamming, has led to a substantial investment to fight against spam. Most techniques for fighting spam use a content analysis approach to identify and block spam emails. Our approach differs in that we propose to characterize the statistical behavior of email servers to determine what features may be used to distinguish servers who are spam forwarders from those that exhibit trustworthy behavior.

Anthony N. Johnson
United States Military Academy at West Point

Development of a Three-Dimensional, Unsplit, Time Dependent Perfectly Matched Layer for Elasto-Dynamic Analyses.

Anthony.Johnson@usma.edu

A time dependent, three-dimensional finite element approach to the development of a perfectly matched layer for numerical calculations of surface wave radiation in a half space is presented. The development of this new element requires the coupling of a system of linear, second-order, partial differential equations which describe elastic wave propagation into a single weak-form (Galerkin) wave equation from which the characteristics of a composite finite element matching layer were derived. Time marching is done via a one step explicit algorithm for solving primary variables without matrix inversion or iterative sub steps. This work develops a methodology for finite element analysis of three-dimensional, semi-infinite, time-dependent elasto-dynamic problems.

Abdoul Kane
University of Toronto

Synchronization in Inhibitory Networks

kane.abdoul@utoronto.ca

We consider a biophysical model describing a network of inhibitory neurons and investigate conditions under which certain specific modes of activity can be observed. By applying techniques from dynamical systems theory we derive a pared-down model that captures the essential features of the model interneuron and also allows an analytical treatment. We then consider a pair of such neurons coupled through GABA-A type synapses and describe how the synaptic time scales interact with the intrinsic dynamics to generate various stable configurations depending on initial conditions and parameters.

Donald King
Northeastern University

Normality and Singularity of Closures of Nilpotent Conjugacy Classes

d.king@neu.edu

The conjugate of a complex symmetric $n \times n$ matrix by a complex $n \times n$ orthogonal matrix is also symmetric. Suppose that Y is an $n \times n$ complex nilpotent symmetric matrix and $\mathcal{O}_Y$ denotes the conjugacy class of Y with respect to $n \times n$ complex orthogonal matrices whose determinant equals one. Let $\overline{\mathcal{O}_Y}$ denote the closure of $\mathcal{O}_Y$ as a subset of $\mathbb{C}^{n\wedge 2}$. $\overline{\mathcal{O}_Y}$ is an irreducible complex algebraic variety. This talk will discuss preliminary work on a few aspects (e.g., normality and singularity) of the geometry of $\overline{\mathcal{O}_Y}$ and relate this geometry to the representation theory of Lie groups. It will focus on several examples involving 3×3 matrices, and curves and surfaces. It will also develop basic notions like normality from scratch.

Asamoah Nkwanta
Morgan State University

Lattice Path and RNA Secondary Structure Predictions

asamoah.nkwanta@morgan.edu

In this presentation we present preliminary research on a lattice path approach to predict (i.e., model or design) certain secondary RNA sequences. In particular we are interested in modeling secondary RNA sequences that are essential for the expression of the SL2 and SL3 domains of the HIV-1 5' RNA molecule. These domains are both hairpin structures that are important for genomic packaging. The overall goal of the presentation is to establish a direct link between certain subsets of lattice paths and secondary RNA sequences of the SL2 and SL3 domains, and to create a mathematical model that predicts more stable HIV-1 RNA sequences.

Ronnie Sircar
Princeton University

Games with Exhaustible Resources

sircar@princeton.edu

We study *N*-player repeated Cournot competitions that model the determination of price in an oligopoly where firms choose quantities. These are nonzero-sum (ordinary and stochastic) differential games, whose value functions may be characterized by systems of nonlinear Hamilton-Jacobi-Bellman partial differential equations. When the quantity being produced is in finite supply, such as oil, exhaustibility enters as boundary conditions for the PDE's. We analyze the problem when there is an alternative, but expensive, resource (for example solar technology for energy production), and give an asymptotic approximation in the limit of small exhaustibility. We illustrate the two-player problem by numerical solutions, and discuss the impact of limited oil reserves on production and oil prices in the duopoly case.

This is joint work with Chris Harris (Cambridge University) and Sam Howison (Oxford University).

Richard A. Tapia
Rice University

The Remarkable Life of the Isoperimetric Problem: The World's Most Influential Mathematics Problem

rat@rice.edu

In contrast to other disciplines in mathematics, problems in optimization are usually quite easy to state and to understand-even for those with limited mathematical sophistication. As such, important optimization problems embedded in some controversy have played a major role in motivating and promoting mathematical activity.

Writing circa 200 BC, the Greek mathematician Zenodorus considered the so-called isoperimetric problem: Determine, from all simple closed planar curves of the same perimeter, the one that encloses the greatest area.

In this talk the speaker will argue that the isoperimetric problem has been the most influential mathematics problem of all time. It played a major role in motivating the calculus of variations activity credited to the Bernoullis, Newton, Euler, and Lagrange in the late 1600's and early 1700's. In turn the early calculus of variations led to the golden era of mathematics that we recognize as the 18th and 19th centuries. Yet a complete proof of the isoperimetric problem eluded these early pioneers. Indeed, it was Weierstrass who first gave a complete proof more than a century later. In this talk the speaker will demonstrate that Euler and later Lagrange were one direct observation away from deriving a sufficiency condition that would have given a straightforward resolution of the isoperimetric problem. The missing ingredient was convexity. We ask rhetorically: was it not known to these two great mathematicians.

Talithia Williams
Harvey Mudd College

Epidemiological Modeling of the Population Dynamics of Cataracts

williams@math.hmc.edu

Although treatable with surgery, cataracts, which give rise to cloudiness or opacity in the normally transparent crystalline lens of the eye, persist as the leading cause of blindness in the world today. In fact, limited resources for cataract surgeries in countries such as Kenya and Ethiopia, leave the population open to blindness deriving from the disease. In this work, we employ statistical inferencing techniques to establish an epidemiological model of the population dynamics for cataracts in an effort to eradicate instances of blindness deriving from the disease. Among the requisite modeling components for disease etiology, we employ sample size, disease duration, age-specific mortality, incidence, and prevalence estimates to establish a modeling platform that serves as a carrier of essential attributes. Given a prescribed population or subgroup, we ultimately establish a dynamic model of the surgical rate, the number of cataract surgeries that should be performed per 1 million people, that eliminates instances of blindness deriving from the disease.

Michael Young
Smith College

Homometric Sets

myoung@smith.edu

Two sets of points, *A* and *B* are said to be *homometric* if the list of distances between pairs of points in *A* is the same as the list of distances between pairs of points in *B*. The size and number of homometric sets of points on a cycle are well studied by crystallographers and music theorists. This talk will ask and discuss some questions about the size of homometric sets on other types of graphs.