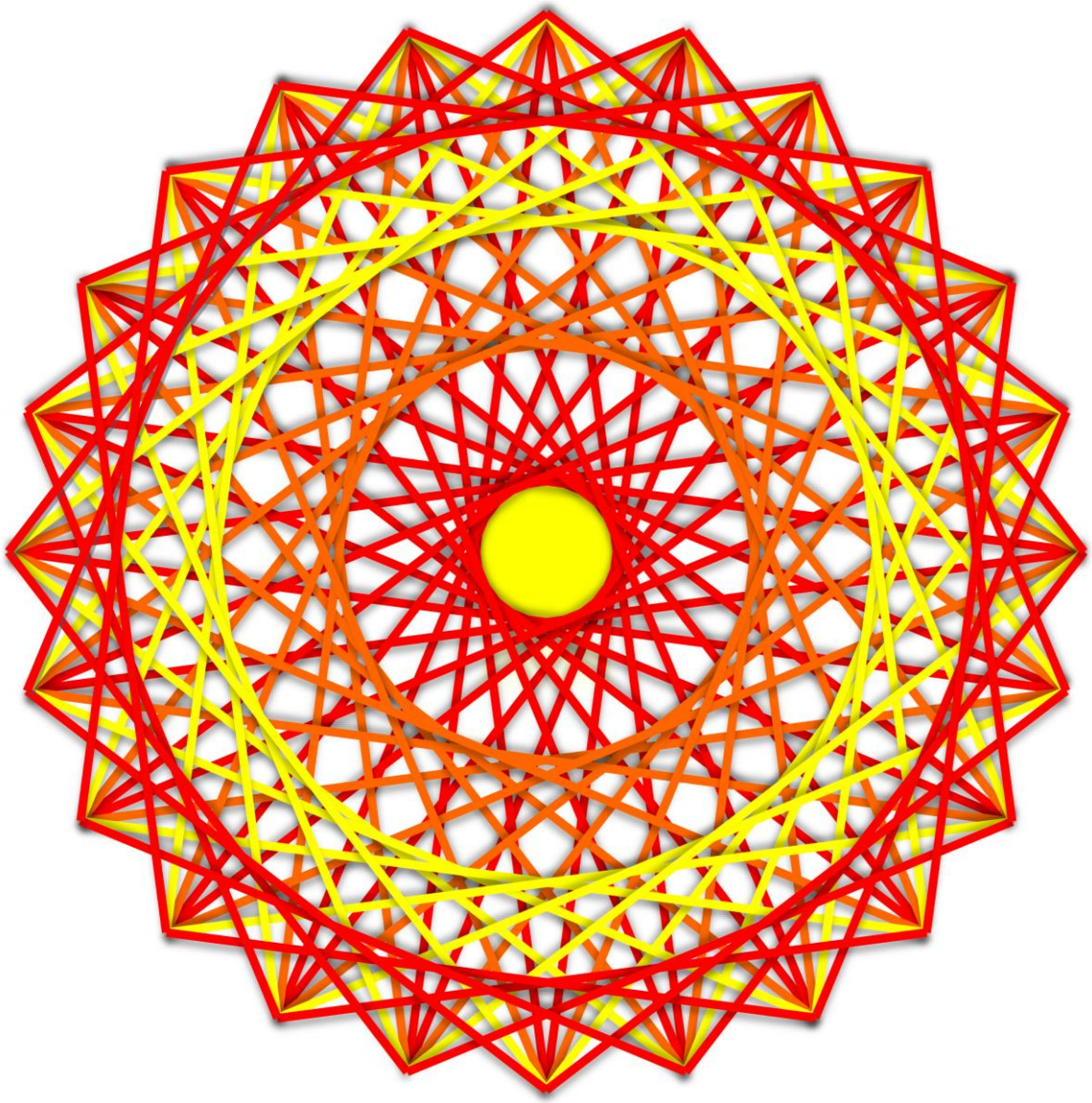

CAARMS24

Student Poster Abstracts

Institute for Advanced Study & Princeton University

July 11th -14th, 2018

ORFE Operations Research & Financial Engineering

1. Faraad Marquis Armwood *North Dakota State University*
Puzzling the Consequences of a Symplectic Condition

2. Zeinab Bandpey *Morgan State University*
Mathematical Counterterrorism Theory: The Structure of Perfect Single Leader Terrorist Cells

3. Joshua Benjamin III *Harvard College*
Constructing the Moduli Space of Elliptic Curves Over a Given Field K

4. Caleb Xavier Bugg *University of California, Berkeley*
Logarithmic Sample Bounds for Sample Average Approximation

5. William Dula *Clark Atlanta University*
Detecting Bovine Lameness Using Three-Dimensional Limb Movement Variable Analysis to Achieve High Sensitivity & Specificity

6. Jean Guillaume *University of Rhode Island*
The Distinguishing Chromatic Number of C_n $(1, k)$, $n, k \in \mathbb{N}$

7. Sibusiso Mabuza *Sandia National Laboratories*
AFC Algorithms in Continuous FE schemes for HD & MHD

8. Taylor McFadden *Elon University*
The Impact of Marijuana and Internet Use on Suicide Rates across the United States

9. Kenneth Morgan, Kyla Winford, Trenise Shivers & Kevin Robinson *SPIRAL Program*
Applied Relationships of Fibonacci Sequences

10. Oluwaseun Ogunmodede *Colorado School of Mines*
Design Optimization Models for Underground Mining

11. Toyya Amber Pujol-Mitchell *Georgia Institute of Technology*
Comparison of Health & Wellness Outcomes between Infants Born to Adult & Teen Mothers

12. Myka Terry *SPIRAL Program*
The Relationship between Pascal's Triangle and Random Walks

13. Cleveland Waddell *North Carolina State University*
Parametric Linear System Solving with Error Correction

14. Derek Young *Iowa State University*
Determining the Maximum Nullity and Field Independence Minimum Rank for Some Graph

Twenty-Fourth Conference for African American Researchers in the Mathematical Sciences
CAARMS24 – Institute for Advanced Study & Princeton University, July 11th – 14th, 2018

Faraad Marquis Armwood

North Dakota State University

Puzzling the Consequences of a Symplectic Condition

faraad.armwood@ndsu.edu

If M has the *symplectic* condition (which we'll define), then we call it a symplectic manifold. This condition is defined by the existence of a smooth 2-form in the *second DeRham cohomology* class. The structure preserving maps are called *symplecto-morphisms*. In the world of Hamiltonian mechanics, symplecto-morphisms are referred to as *canonical transformations*. These transformations are important since they preserve Hamilton's Equations.

If you're a geometer, the definition of geodesics can be redefined as the minimum of a Hamiltonian. A Hamiltonian is now just a real-valued function on a symplectic manifold. One can easily get such a map by using "graph coordinates". Hence, if you're one who likes Hamiltonian systems, symplectic topology can provide you with many. If you're a topologist like myself, the story now begins.

It turns out that even-dimensional Euclidean space $\mathrm{E}(2n)$ is a symplectic manifold and quickly proves to be a very fruitful example to study. There's a "nice" relation one can formulate with the standard dot-product, the symplectic form on $\mathrm{E}(2n)$ and a rotation matrix of $\mathrm{E}(2n)$ that gives rise to another class of manifolds, called almost complex manifolds. This is the class of symplectic manifolds with a "compatible" complex structure.

There's also another class called *Kähler manifolds*. These are manifolds with compatible complex, symplectic and Riemannian structure. They're also a bit more complicated in formulation since we have to define complex forms. In any case, we have 3 new classes of manifolds to study! One now has many questions to explore:

1. Are there symplectic manifolds which aren't Kähler?
2. Which aren't almost-complex?
3. Is the connected sum of two symplectic manifolds also symplectic?
4. Which surgeries produce symplectic/Kähler/almost complex manifolds?
5. Which perturbations of these manifolds preserve their structure?
6. Can you perform a surgery on a manifold in one class that takes you to another?

In answering questions like the first two, one begins to piece together the consequences (the new manifolds) in the box of even-dimensional Riemannian manfiolds. Hence, we're "Puzzling the Consequences of a Symplectic Condition".

Zeinab Bandpey

Morgan State University

Mathematical Counterterrorism Theory:
The Structure of Perfect Terrorist Cells with a Single Leader

Zeinab.bandpey@morgan.edu

Terrorist cells are modeled as finite partially ordered sets. This paper determines the structure of the terrorist cell most likely remain intact if a subset of its members is captured at random, provided that the cell has a single leader and no member has more than b immediate subordinates. Jonathan Farley solved the problem for the case $b = 2$. Campos, Chvátal, Devroye, and Taslakian (the chairman of Stanford University's Computer Science Department at one time called Vašek Chvátal "one of the two best young combinatorialists in the world") solved the problem for class of trees.

Joshua Benjamin III

Harvard College

Constructing the Moduli Space of Elliptic Curves Over a Given Field K

jbenjamin@college.harvard.edu

Studying a single instantiation of an object can be insightful, but it is often desirable to study families of the object at once. Choosing how one will identify "equivalent" objects and then choosing a suitable parameter by which to allow objects in the family to vary is what a classical moduli problem consists of. Elliptic curves have long been studied in geometry, but they received an increase in attention after connections with number theory were exploited due to their nature as abelian varieties. Typically, one wants what is known as a fine moduli space which solves the moduli problem and also carries a universal family that satisfies certain properties, but this is often not possible.

In this survey, I explain why this is not always possible, and offer the two common ways around this problem. One is to settle for what is called a coarse moduli space, which in the case of elliptic curves, leads to the notion of the modular curves $Y(\Gamma)$ and $X(\Gamma)$. The other option is to enlarge the category of schemes as one does with the enlargement of the category varieties to schemes. This leads to the notion of stacks like $\mathcal{M}_{1,1}$. The Survey concludes with new problems that arise in classifying elliptic curves up to isogeny rather than isomorphism, and fundamental questions about the geometry of these moduli spaces.

Caleb Xavier Bugg

University of California, Berkeley

Logarithmic Sample Bounds for Sample Average Approximation

caleb_bugg@berkeley.edu

The Sample Average Approximation (SAA) method is commonly used to approximately solve stochastic optimization problems, and it often works better in practice than existing theoretical bounds suggest for the number of samples needed to ensure the SAA minimum value is close to the true minimum value.

In this project, we derive new theoretical bounds for SAA that, for certain types of constraint sets, are logarithmic in problem dimension, whereas existing bounds are polynomial in dimension. Our approach characterizes the stability of random instances of the optimization problem using stochastic process theory, and then uses this characterization to construct confidence intervals using concentration of measure techniques.

Notably, for single stage stochastic optimization problems, we find that the presence of an L1 constraint yields logarithmic bounds on the number of samples needed. This provides theoretical explanation for the success of SAA for capacity- or budget-constrained problems.

William Dula

Clark Atlanta University

Detecting Bovine Lameness Using Three-Dimensional Limb Movement Variable Analysis to Achieve High Sensitivity & Specificity

william.dula@students.cau.edu

Bovine lameness is a common issue among commercial dairy farms, resulting in decreased productivity. In order to treat bovine lameness effectively, it is necessary that it is detected early. The main objective is to model the lameness status of a cow using three-dimensional limb movement measurements related to the cow's gait. Previously, a statistical model was generated using the software SAS with its LOGISTIC and TRANSREG procedures. The model produces a binary classification: lame or sound. Current implementation requires running several SAS procedures manually and therefore is not amenable to a large scale application.

In this work, we implement regression algorithms in R to mirror the TRANSREG procedure and thus speed up exploration of a large number of candidate models to maximize goodness of fit criteria such as the area under the Receiver Operating Characteristic curve (AUC). The predictive models are also evaluated using quantities such as sensitivity (true positive rate) and specificity (true negative rate) which are quite important from the dairy industry's point of view. We also consider multinomial logistic models to divide the lame cows further into severely lame and mildly lame. These results can ultimately be used in the commercial dairy industry for early lameness detection.

Jean Guillaume

University of Rhode Island

The Distinguishing Chromatic Number of $C_n\ (1, k)$, $n, k \in \mathbb{N}$

Jean_guillaume@uri.edu

Let's say we have a ring of n seemingly identical keys, which are assigned to different doors, and our goal is to be able to distinguish them using a variety of handle shapes. From the point of view of graph theory, this is finding out how many labels (colors) are needed to distinguish the vertices of C_n, so that the only label-preserving (color-preserving) automorphism for C_n isthe identity. Extending this idea to any graph G, we want to label the vertices in a way that destroys the symmetries of the graph. Let r be the number of labels used to accomplish this goal; we thus say that G has an $r\ distinguishing\ labeling$ and the $distinguishing\ number$ of G, denoted $D(G)$, is the minimum r such that G has an r distinguishing labeling. Furthermore, if we attain this objective using a proper labeling, then we call the minimum$r$the $distinguishing\ chromatic\ number$ of G. From this presentation, the audience will learn about the history (very recent), some known results (surprising to say the least) and our new results for the subclass of circulant graphs, $C_n(1, k)$.

Sibusiso Mabuza

Sandia National Laboratories

AFC Algorithms in Continuous FE schemes for HD & MHD

smabuza@sandia.gov

We consider a linearity preserving algebraic flux correction (AFC) algorithm for the stabilization of *magnetohydrodynamics* (MHD) systems. The MHD equations, with some divergence cleaning, are discretized using piece-wise linear continuous finite elements. The stabilization of the scheme follows the flux corrected transport paradigm by introducing some diffusion into the system, whose amount is regulated by solution dependent element and nodal limiters. The limiter is designed to be linearity preserving so to ensure that in smooth regions, second order convergence is observed for smooth solutions. The limiters are also designed such that they continuously dependent on data, guaranteeing solvability of the semi-discrete scheme. The limiting strategy allows for flexible assembly, and utilization of various time steppers. We consider a number of standard inviscid HD and MHD examples in 1D and 2D on quad and simplex meshes. We also demonstrate the robustness of the scheme using various implicit and explicit time integrators.

Taylor McFadden

Elon University

The Impact of Marijuana and Internet Use on Suicide Rates across the United States

tmcfadden2@elon.edu

Suicide is amongst the top 10 leading causes of death in the United States. Each year approximately 44,965 Americans die by suicide. In the past decade, suicide rates have steadily increased in nearly every state in the U.S. from 1999 through 2016, rising a concerning 25.4 percent in the U.S as a whole. Mental health conditions are often perceived as being the underlying cause of suicide. However, suicide is rarely caused by any single factor. There are many contributing factors to the increase in suicide rates across the country. Factors such as mental health and unemployment have been previously studied. In this paper we examine the impacts of variables that have been insufficiently studied, such as internet usage and marijuana use, on suicide rates in the United States.

Kenneth Morgan, Kyla Winford, Trenise Shivers & Kevin Robinson

SPIRAL at Morgan State University

Applied Relationships of Fibonacci Sequences

morgan6.kenneth@gmail.com, kyla.winford@gmail.com
trenise.shivers@students.cau.edu & kevin.robinson@gmail.com

The Fibonacci number sequence was created by a famous mathematician named Leonardo Pisano Bigollo (born in 1175 – died in 1250). They have many real world applications. This number sequence has an exact formula which uses the *golden ratio*.

Our objective is to define the classical Fibonacci sequence and then deduce the *Binet formula* for the Fibonacci sequence using two different methods. The first method will use combinatorial arguments through generating functions. The second method uses the linear algebraic techniques of eigenvalues and eigenvectors. Finally we develop Binet type formulae to generalize Fibonacci sequences (Lucas numbers for example). The theorems we have studied have come from different mathematical sources ranging from the late 1800's until the modern era.

Oluwaseun Ogunmodede

Colorado School of Mines

Design Optimization Models for Underground Mining

oogunmod@mines.edu

We address design optimization problems for a mine in a high-level early-stage planning phase. First, we evaluate the economic potential of the ore body when using, a so-called, top-down open-stoping mining method The mining method requires that lateral compressional forces are mitigated by forgoing the extraction of potentially profitable blocks, while the remaining scheduled for extraction with the goal of maximizing total profit of the extracted ore. We use an integer programming based heuristic to create a design that maximizes profit subject to geotechnical stability.

Secondly, we approach the problem from an NPV perspective by evaluating competing mining methods. We compare a bottom-up approach with the method described above. We formulate the problem as a multi-mode resource-constrained scheduling problem with mode-dependent precedence constraints, and take advantage of mining-specific structure to generate a design that maximizes NPV while adhering to geotechnical constraints.

The third problem we explore is from a production scheduling with ventilation perspective. Heat limitations are largely ignored despite contributors to heat output such as: (i) the equipment used for underground activities, e.g., development and extraction; (ii) auto compression and etc. We incorporate heat considerations into a resource-constrained production scheduling model using knapsack constraints. The model maximizes NPV subject to additional constraints on precedence and other resource limiting factors. The model produces more realistic schedules that could increase revenue by lowering ventilation costs for the mine-specifically; refrigeration costs for the underground mine.

Toyya Amber Pujol-Mitchell

Georgia Institute of Technology

Comparison of Health and Wellness Outcomes between Infants Born to Adult and Teen Mothers

pujol@gatech.edu

This research focuses on the impact of teen pregnancy on the health and wellness of infants insured my Medicaid. We investigated the following measure outcomes were: health status, low birth weight, foster care, infant mortality within the first 12 months of live, neonatal abstinence syndrome, number of wellness visits, and number of emergency department visits.

We identified all teen mothers, insured by Medicaid, who gave birth in 2011, and paired them with their respective infant based on an iterative pairing process. Next, to isolate the treatment effect, we used the propensity scoring method of matching. We matched the teen mothers to adult mothers with similar demographics and compared the outcomes of the teen mother infants and the adult mother infants. Further analysis was performed to assess differences by urbanicity and race.

Myka Terry

SPIRAL Program

The Relationship Between Pascal's Triangle and Random Walks

myter1@morgan.edu

Random walks, also known as *Dyck paths*, are a series of equal length up, down, and level steps that enumerate distinct paths from $(0,0)$ to $(2n,0)$ in the first quadrant of the Cartesian plane. We used Dyck paths to analyze Catalan, Schröder, and Motzkin number series through a combination of induction, matrices and quadratic functions. Our results revealed a number of distinct patterns, some unnamed, between these number series and Pascal's triangle that can be explained through generating functions, first returns, group theory and the Riordan Matrix.

Various proofs and properties regarding these number series are provided, including the generating functions, their respective first returns, and matrix properties. Our findings lead to a deeper understanding of combinatorics and graph theory.

Cleveland Waddell

North Carolina State University

Parametric Linear System Solving with Error Correction

cawaddel@ncsu.edu

In Kaltofen, Pernet, Storjohann, and Waddell [Proc. ISSAC 2017], we presented an algorithm for solving black box linear systems where the entries are polynomials over a field and the matrix of the system has full rank. The algorithm takes degree bounds for a solution as input and returns a solution that satisfies the degree bound. The solution can be found even if some evaluations are erroneous. The algorithm computes simultaneously and returns an error locator polynomial. This algorithm, however, does not work when the matrix of the system is rank deficient and some evaluations are errors.

We present now an algorithm for solving black box linear systems where the entries are polynomials over a field and the matrix of the system is rank deficient. The algorithm first locates and removes all errors, after which it computes a solution that satisfies the input degree bounds.

Derek Young

Iowa State University

Determining the Maximum Nullity and Field Independence Minimum Rank for Some Graph

ddyoung@iastate.edu

In 2008, it was shown that the maximum nullity of a graph could be bounded above by the zero forcing number of the graph. We study techniques for determining the value of the maximum nullity for some regular graphs such as the Cartesian product of the cycle and path, extended cube graph, and circulant graphs. One technique uses the *strong Arnold property* to bound the maximum nullity below. It is known that the Colin de Verdiére number is a lower bound for the maximum nullity but the value is not easily determined. Equitable partitions on the graph's vertex set and a newer technique to decompose the adjacency matrix are both used to establish the eigenvalues of the adjacency matrix for the graph. They can be used to determine minimum rank field independence for some graphs.