Abstracts

Abigail Miller  Mathematical modeling of the ANWR ecosystem

Callinectes sapidus, or the blue crab, is a crustacean that is vital to the survival of the whooping cranes (Grus americana) and the ecosystem supported at Aransas National Wildlife Refuge (ANWR). The crabs serve as a keystone organism because of their direct and indirect relationships with neighboring species, including their role as a favorite food source for the cranes. In order to effectively model the ecosystem of ANWR, we must accurately model the hydrology and blue crab population within the region. A population model which predicts abundance and distribution of blue crabs can be simulated through an agent-based program. This model helps us understand how hydrological conditions are linked to blue crab populations in ANWR.

Brandy Doleshal  Primitive/Seifert knots

The primitive/primitive knots lie in the genus 2 Heegaard surface, F, for the 3-sphere, in such a way that they are guaranteed a lens space surgery at the surface slope. It is known that distinct primitive/primitive knots can yield the same lens space surgery after surgery at the surface slope. The primitive/Seifert knots, a generalization of the primitive/primitive knots, lie in F in such a way that they are guaranteed a Seifert fibered space surgery at the surface slope. The speaker will outline a years-long quest to answer the question: Can distinct primitive/Seifert knots yield the same Seifert fibered space surgery after surgery at the surface slope?

Daewa Kim  A kinetic theory approach to pedestrian motion

In recent decades, interest in the modeling of crowd dynamics has increased due to many applications in engineering and social sciences. In this talk, we can see the modeling of the evacuation of a crowd from bounded domains by kinetic theory approach. The modeling approach deals with dynamics caused by interactions of pedestrians not only with all the other pedestrians, but also with the geometry of the domain, such as walls and exits. Numerical simulations are developed to consider the trend to move toward the exit and to avoid the collision with walls, and the tendency to move towards less congested areas and to follow the stream unconsciously.

Daniela Ferrero  Power domination and zero forcing applied to electrical power networks

Electric power companies need to monitor the state of their networks continually in order to prevent power surges and black-outs. One method to accomplish this task is to place Phase Measurement Units (PMUs) at selected network locations. The synchronized readings provided by these PMUs, in conjunction with Kirchhoff’s laws, permit to determine the state of the network at any location. Because of the high cost of a PMU, it is important to minimize their
number while maintaining the ability of monitoring the entire system. This problem translates into the power domination problem in graph theory.

In this talk we will present a connection between the power domination problem in graph theory and the zero-forcing problem in linear algebra, and show how the interplay between those problems allows to advance the state-of-the-art in both problems as well as in some extensions of both, zero-forcing and power domination. The results are joint work with several colleagues.

Daria Kurzanova  

*A robust preconditioner for high contrast problems*

Current project concerns robust numerical treatment of an elliptic PDE with high contrast coefficients. We introduce a saddle point description with a semi-positive definite matrix of the corresponding discrete problem and propose a robust preconditioner for the Lanczos method used for solving it. Numerical examples are presented.

Elizabeth Stephenson  

*A Mathematical Model of Skeletal Muscle Regeneration*

While the cellular mechanisms behind mammalian skeletal muscle regeneration have been rigorously studied in the past forty years, no mathematical models have previously been established to demonstrate the regenerative process, except in the cases of extremely specific diseases. The goal of this project is to construct a system of ordinary differential equations that effectively models the regeneration of damaged, but disease-free, mammalian skeletal muscle on a cellular level. This can aid the scientific and medical communities as they seek to more effectively heal patients with damaged muscles. A system of seven ordinary differential equations is introduced to model the interactions between classically and alternatively activated macrophages, satellite cells, myoblasts, myotubes, healthy myofibers, and damaged myofibers. The equations incorporate the sequential, overlapping stages of muscle regeneration following injury: immune response and subsequent cell proliferation, differentiation, and fusion. The system of differential equations is mathematically analyzed, yielding one biologically meaningful stable equilibrium which suggests complete muscle recovery. A set of numerical simulations is performed using Matlab to illustrate the performance of the proposed equations and to model the effects of common treatments such as NSAIDs (nonsteroidal anti-inflammatory drugs such as ibuprofen). The ability to mathematically forecast the outcome of changes in medication could prove useful in healing damaged muscle faster and more completely. Next, we plan to collaborate with colleagues researching bone rehabilitation to explore the interactions between muscle and bone in the regenerative process.

Fatma Terzioglu  

*Image Reconstruction from Compton Camera Data*

In this presentation, we address analytically and numerically the inversion of the integral transform (cone or Compton transform) that maps a function on $\mathbb{R}^n$ to its integrals over conical surfaces. It arises in a variety of imaging
techniques, e.g. in astronomy, optical imaging, and homeland security imaging, especially when the so called Compton cameras are involved. We present several inversion formulas for the cone transform and the results of their numerical implementation in two and three dimensions.

**Jacqueline Jensen-Vallin  Gilbreath Knots**

We will examine what happens when analysis meets knot theory. In particular, we will examine knots whose Conway notation is derived from a Gilbreath sequence of integers. A Gilbreath sequence is a sequence of (usually) natural numbers $a_1, a_2, a_3, \ldots, a_n$ such that all subsequences $a_1, a_2, \ldots, a_m$ with $m \leq n$ contain consecutive natural numbers. We will build knots corresponding to Gilbreath sequences and examine properties of those knots.

**Jen Berg  Integral solutions of polynomial equations and reciprocity laws**

One problem of great interest in number theory is determining whether a polynomial equation has a rational or integral solution. A necessary first step is to determine whether the equation is "locally soluble", that is, to find a solution with coordinates in the real numbers and modulo each positive integer. However, local solubility is generally not sufficient to guarantee a "global" (integer or rational) solution. In order for local solutions to come from a common global solution, it turns out that they must satisfy certain compatibility conditions that can arise from quadratic reciprocity and higher reciprocity laws. These conditions are known as the Brauer-Manin obstruction. In this talk, I will provide examples of equations that fail to have global solutions despite the existence of local solutions, and explain how they fit into this framework.

**Kun Wang  Classification of C*-algebras**

I will talk about my research on classification of C*-algebras. Moreover, I will introduce the invariant we use and relation between different invariants.

**Lorena Galvan  Encouragement for the New Generation of women in mathematics and related fields**

**Nida Obatake  "Rat GPS" – Drawing Place Field Diagrams of Neural Codes Using Toric Ideals**

A rat has special neurons that encode its geographic location. These neurons are called place cells and each place cell points to a region in the space, called a place field. Neural codes are collections of the firing patterns of place cells. In this talk, we investigate how to algorithmically draw a place field diagram of a neural code, building on existing work studying neural codes, ideas developed in the field of information visualization, and the toric ideal of a neural code. This talk is based on joint work with Elizabeth Gross (San Jose State University) and Nora Youngs (Colby College) [see: arXiv:1607.00697].
Pritha Chakraborty  
*On a conjecture of Korenblum in Bergman Spaces*

B. Korenblum conjectured in 1991 and W. Hayman proved in 1992 that for \( f, g \in \mathcal{A}^2(D) \), there is a constant \( c, 0 < c < 1 \), such that if \( |f(z)| \leq |g(z)| \) for all \( z \) such that \( c \leq |z| < 1 \), then \( \|f\|_2 \leq \|g\|_2 \). Here, \( \mathcal{A}^2(D) \) is the set of square integrable analytic functions in the unit disc \( D \). The largest possible value of such \( c \) is called the Korenblum’s constant. The exact value of this constant, which is denoted by \( \kappa \), remains unknown. I will discuss some non-linear extremal problems in Bergman spaces and prove some results which will shed some light on the Korenblum’s conjecture.

Sara Shirinkam  
*Numerical algebraic geometry for identifying the number of components in Gaussian Mixture Models*

Gaussian Mixture Models (GMM) are among most statistically mature methods for clustering and density estimation with numerous successful applications in science and engineering. GMM parameters are typically estimated from training data using the iterative Expectation-Maximization (EM) algorithm, which requires the number of Gaussian components apriori. In this study we proposed a numerical algebraic geometry approach to identify the optimal number of Gaussian components in GMM. The proposed approach transforms GMM models with various number of components into equivalent polynomial regression splines and uses homotopy continuation methods to find the model or equivalently the number of components which is most compatible with training data. The proposed approach also identifies the location of all local maxima of the equivalent polynomial regression model which accurately estimates the location of Gaussian components centers. We compare the performance of the proposed approach against popular methods in the literature which are based on Akaike information criterion (AIC) and Bayesian Information Criterion (BIC) using extensive simulation.

Sat byul Seo  
*A Finite Difference Method of Second-Order Heat Diffusion Equations with Discontinuous Coefficients in 3-D*

A finite difference method has been developed and it allows a different value for each sub-region of interfaces, and the method has the diffusion coefficient second order accuracy. We propose this method in three dimensions for a cubic domain and we prove its with second order accuracy. This method is used to show independency of signaling for synaptic transmissions by solving differential equation numerically to obtain concentrations of Glutamate on synapses.

Simona Hodis  
*Mind the gap: impact of arterial wall thickness on assessment of arterial stiffness*

Pulse Wave Velocity (PWV) is commonly used clinically as a method of detecting vascular stiffening. This method is based on the Moens-Korteweg formula, which describes the PWV in ideal elastic and thin wall tubes. The extent to which the assumption of the arterial wall thickness being negligible is satisfied in the cardiovascular system is not known because the thickness
varies widely across different regions of the vascular tree and under different pathological conditions. In this study we show that an expansion for small wall thickness of the classical solution of this problem does not in fact lead to valid results for values of thickness that are not infinitely small. An alternative solution for large values of thickness is presented, together with a method of patching the two solutions.

**Ummugul Bulut**  *Derivation of the Biased and Correlated Random Walk Models in One and Two Dimensions*

Stochastic partial differential equations are derived to model the biased and correlated random walk (BCRW) on one and two dimensions. Deterministic equation is known for one dimensional BCRW where particles have a tendency to move a particular direction, either right or left. In the present investigation, discrete time stochastic models are developed by determining the possible changes in direction for a small time interval. As the time interval decreases, the discrete stochastic models lead to systems of ITO stochastic differential equations. As the position intervals decrease, stochastic partial differential equations are derived to model BCRW in one and two dimensions. Comparisons between numerical solutions of the stochastic partial differential equations and independently formulated Monte Carlo calculations support the accuracy of the derivations. keywords: Mathematical modeling, CRW models, stochastic differential equations, Monte Carlo simulation.