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?

Cornelia Mihaila *The shape of capillarity droplets in a container*

The capillarity droplet problem concerns the minimization of the Gauss free energy of a set, where the Gauss free energy is defined as the sum of the surface and potential energies of that set. In this talk, we consider minimizers of the Gauss free energy for a liquid droplet bounded in a container with nice boundary. We discuss a quantitative description of the shape of global minimizers and their regularity properties in the small volume regime. This work was performed in collaboration with Francesco Maggi.

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 Lancsoz 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.

Lisa Piccirillo *On the Akbulut-Kirby Conjecture*

A pair of knots are said to be smoothly concordant if they cobound, in $S^3 \times I$, a smooth properly embedded annulus. Zero surgery on a knot is a construction for building a three manifold from S^3 by cutting out a tubular neighborhood of a knot and reattaching it differently. A classical conjecture of Akbulut and Kirby says that if a pair of knots have diffeomorphic zero surgeries then the knots will be concordant. This was disproven in 2015 by Kouichi Yasui. However, if one insists that the knots in question have diffeomorphic traces this problem remains open. We'll talk about some techniques for addressing this as well as applications of these problems to questions about shake genus and invertible satellite operators.

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 $f,\ g \in \mathcal{A}^2(\mathbb{D})$, 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, $\mathcal{A}^2(\mathbb{D})$ is the set of square integrable analytic functions in the unit disc $\mathbb{D}$. The largest possible value of such c is called the Korenblum's constant. The exact value of this constant, which is denoted by κ, 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 *A Computational Algebraic Approach for model selection in Gaussian Mixture Models*

Selection of the number of mixing components is an important problem in finite mixture modelling. In this study we use numerical algebraic geometry methods to select the optimal components in Gaussian mixture models. First, GMM models of various number of clusters are fitted to training data. Next, each GMM model is approximated by a polynomial regression spline. Then, the associated regression models are evaluated based on test data using homotopy continuation methods to find the model most compatible with test data. Simulation data analysis is used to show the consistency of the proposed method in determining the number of components.

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.

Shelly Harvey *Using gropes to define a non-discrete metric on the knot concordance group*

A knot is a embedding of the circle into $\mathbb{R}^3$. Using a 4-dimensional equivalence relation on knots, called concordance, one can make the set of knots up to concordance into an infinitely generated abelian group called the knot concordance group, C. Most of the 50-year history C has focused on its structure as an abelian group. Recently Tim Cochran and I took a different approach, namely we studied C as a metric space (with the slice genus metric) admitting many natural geometric operators. The hope was to give evidence that the knot concordance space is a fractal space. However, both of these metrics are integer valued metrics and so induce the discrete topology. Here we define a family of metrics, called the q-grope metrics ($q \to 1$), which take values in the real numbers. We will show that there are sequences of knots whose q-norms get arbitrarily small for $q > 1$. We will also show that for any winding number 0 satellite operator , $R : C \to C$, there is an interval for q such that R is a contraction operator. This talk will be accessible to a general audience. This is joint work with Tim Cochran and Mark Powell.

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.