
▷ Mathematical Model of Asynchronous Respiratory Mechanics

Richard Foster

`https://youtu.be/0xCYMpkOn1I`

Asynchronous breathing is a compromised state that can preclude chronic lung disease. We constructed a respiratory model with interpolated rib cage and abdomen component compliances to model asynchrony. Results indicate asynchronous volume changes associated with an unequal distribution of effort to each component.

▷ Caterpillar Game Chromatic Number

Paige Beidelman

`https://youtu.be/ZsJmvJe3InA`

In the graph coloring game, two players, Alice and Bob, alternate to properly color, so Alice wins if every vertex is properly colored with k colors. The least number of colors needed for Alice to have a winning strategy is the game chromatic number. We classified the chromatic number of caterpillar graphs with at least one vertices of degree 2, 3, and 4.

▷ Generalizations of Alder's Conjecture via a Conjecture of Kang and Park

Simran Khunger

`https://youtu.be/LAyCUC58zjw`

There are numerous identities regarding integer partitions, two of these being the Rogers-Ramanujan identities. We show a recent conjecture that generalizes the 2nd Rogers-Ramanujan identity, a proof of it for all but finitely many cases, and finally an extensive generalization of this identity with a partial proof.

▷ Clique Partitions of Random Graphs

Kalen Patton, He Guo

`https://youtu.be/OOIGN1L-WGM`

A clique partition of a graph G is a collection of edge-disjoint cliques which contain each edge of G exactly once. A natural question to ask is: what is the smallest clique partition of G? We examine this question for the random graph G(n,p), using a random algorithm to derive strong order-of-magnitude bounds.

▷ SVD and its Applications

Katie Keegan, David Melendez, Jennifer Zheng

`https://youtu.be/7OqSwOr_pbs`

The singular value decomposition, or the SVD, was first discovered independently by Eugenio Beltrami and Camille Jordan in the 1870s as they were tackling problems related to bilinear forms in linear algebra. Since then, it has become one of the most useful tools in linear algebra, seeing applications in widely disparate fields. In this talk, we will introduce applications of the SVD in image, video, and audio processing, data analysis, and digital ownership protection. We provide several examples illustrating applications and properties of the SVD, including image and audio compression, image and audio processing, video background extraction, analysis of data from the SARS-CoV-2 pandemic, and watermarking for digital ownership protection. Finally, we propose a modified version of a watermarking scheme introduced in Liu & Tan and Jain et al. which offers improved robustness and imperceptibility properties.

▷ Modeling the Population Dynamics of Paleo-Oysters from the Pleistocene Epoch

William Glembocki

`https://youtu.be/gCJwUEa-Gus`

Oysters are vital to the ecology and economy of the Chesapeake Bay, but their population has fallen to less than 1% of historic levels. We used data on paleo-oysters to adjust an integral projection model to investigate the population dynamics of large, high-fecundity oysters in the Pleistocene Epoch.

▷ Knotris: Gameplay & Probability

Kelemua Tesfaye

`https://youtu.be/7reHOd9kWaM`

Knotris is a new game we have developed based on mosaic knot theory. In this talk, I will discuss probabilities related to gameplay and how they give us insight into game strategies. I will also describe how coding has helped us to determine both strategy and which game states are more difficult to play within. This analysis has informed our game design.

▷ Magician Reveals Their Secret: Ensley Vallin 4 Card Trick

Ashley Armbruster

`https://youtu.be/UgLc48Pa8Rg`

In the Ensley Vallin trick, four cards, with one in "dissenting" facing, are

rotated and pancaked flipped as often and in any sequence until the participant is satisfied. After a terminating move and without looking at the cards, the magician announces which card is dissenting. We prove that this trick always works!

▷ Multigrid for Fourier Finite Element Methods on Axisymmetric Domains

Trevor Crupi, Yonah Moise, Hannah Odom

`https://youtu.be/VDccVsrPIts`

Finite Element Methods (FEMs) are some of the most widely used techniques for approximating solutions to both ordinary and partial differential equations. FEMs have a wide range of applications in physics and engineering including thermodynamics, structural analysis, and fluid dynamics. To obtain close approximations, FEMs must solve very large matrix systems in which classical methods can be very inefficient. Because of this, many different iterative methods have been created to compute solutions to large matrix systems more efficiently. For FEMs, the convergence properties of these iterative methods can depend on the Sobolev spaces that the problem is defined in. Our primary goal is to show that the Multigrid V-cycle iterative algorithm can be utilized to efficiently solve Fourier Finite Element Methods (Fourier-FEMs) posed in weighted H(curl) spaces on axisymmetric domains, and how this method compares to other iterative methods. We show numerically that in boundary value problems posed in these weighted H(curl) spaces over axisymmetric domains, the Multigrid V-cycle with modern smoothers converge uniformly with respect to mesh sizes. Numerical results also indicate that for larger Fourier modes, the convergence rate decreases slightly compared to lower integer values for Fourier modes.

▷ The Sunflower Problem

Tolson Bell, Suchakree Chueluecha

`https://youtu.be/iYR9bzy7yvo`

The goal of the sunflower problem is to find the smallest $r = r(p, k)$ such that every family of at least r^k k-element sets must contain a sunflower with p petals. Major breakthroughs by Alweiss-Lovett-Wu-Zhang and others show that $r = O(plog(pk))$ suffices. In this talk, we present our improvement to $r = O(plog(k))$.

▷ Counting Restricted Partitions of Integers into Fractions

Zachary Hoelscher

`https://youtu.be/TLjLStAw5UQ`

Motivated by the study of integer partitions, we consider partitions of integers into fractions of a particular form, namely with constant denominators and distinct odd or even numerators. When numerators are odd, the numbers of partitions for integers smaller than the denominator form symmetric patterns. If the number of terms is restricted to h, then the nonzero terms of the generating function are unimodal, with the integer h having the most partitions. Such properties can be applied to a particular class of nonlinear Diophantine equations. We also examine partitions with even numerators. We prove a partition identity involving the prime omega function, where we examine partitions of an integer t into fractions with the first x consecutive even integers for numerators and equal denominators of y, where 0¡y¡x¡t. We then use this to produce corollaries such as a Dirichlet series identity and an extension of the prime omega function to the complex plane, though this extension is not analytic everywhere.

▷ On the t-Target Pebbling Conjecture

Essak Seddiq

`https://youtu.be/P23a8eGGbrs`

Graph pebbling is a network optimization model for satisfying vertex demands with vertex supplies (called pebbles), with partial loss of pebbles in transit. The pebbling number of a demand in a graph is the smallest number for which every placement of that many supply pebbles satisfies the demand. The t-Target Conjecture (Herscovici-Hester-Hurlbert, 2009) posits that the largest pebbling number of a demand of fixed size t occurs when the demand is entirely stacked on one vertex. The truth of this conjecture could be useful for attacking many open problems in graph pebbling, including the famous conjecture of Graham (1989) involving graph products. It has been verified for complete graphs, cycles, cubes, and trees. In this seminar I will offer a brief history on the subject, define key concepts and lemmas, and explore how we used such ideas to prove the conjecture for various chordal graphs.

▷ Pattern Avoidance in Cyclic Permutations

Alexander Sietsema, Jamie Schmidt

`https://youtu.be/n4iuk5xlpM0`

Pattern avoidance in permutations is a well-studied field of enumerative combinatorics. We will discuss the classical version for linear permutations and then introduce a recent variant for cyclic permutations. Finally, we will present our new results counting cyclic avoidance sets for pairs of length 4 patterns, and give an example of how those results arise from counting arguments.

▷ Prime Walk to Infinity in $Z[\sqrt{2}]$

Daniel Sarnecki, Bencheng Li

`https://youtu.be/1fhOzsGwEhY`

An interesting question known as the Gaussian Moat problem asks whether it is possible to walk to infinity along the Gaussian primes with a bounded step size. We examine a similar version of this problem in the real quadratic integer ring $\mathbb{Z}[\sqrt{2}]$ whose primes mostly cluster along the asymptotes $y = \pm x/\sqrt{2}$ as compared to the Gaussian primes, which mainly cluster at the origin. A probabilistic model of primes $a + b\sqrt{2}$ in $\mathbb{Z}[\sqrt{2}]$ is then constructed according to their norms $a^2 - 2b^2$ by applying the Prime Number Theorem and a combinatorial theorem for counting the number of lattice points in the region $|a^2 - 2b^2| \leq n^2$. Lastly, we perform a few moat calculations in $\mathbb{Z}[\sqrt{2}]$ for various step sizes and make a conjecture about the existence of a prime walk to infinity.

▷ Commutativity of Noisy Matrices

Anshu Sharma

`https://youtu.be/a0kirb3OY0U`

This talk will discuss Pearcy and Shield's 1979 theorem relating almost commutating and nearly commutating matrices, other measures of commutating matrices involving diagonalization and eigenvectors, and an empirically supported finding relating the magnitudes of matrix noise to the magnitude of the commutator.

▷ Regulating the Right to Bear Arms

Josephine Messina

`https://youtu.be/FyuFg2cPySM`

This analysis developed multiple linear regression models for state firearm mortality, suicide, robbery, and assault rates in order to determine if gun control policies had a significant effect on reducing violence. Several gun control policies were shown to lower firearm mortality and suicide rates in 2018.

▷ An Improved Interpolative Decomposition

Rishi Advani, Madison Crim, Sean O'Hagan

`https://youtu.be/C1D3yBpKJ6Y`

With high-dimensional data, it is often easier to work with a low-rank approximation to the data matrix. An interpolative decomposition (ID) is an approximation that preserves some of the original columns of the matrix. We introduce a novel algorithm for computing an ID that outperforms the

current state of the art.

▷ Generalizing Zeckendorf's Theorem to Linear Recurrences

Clayton Mizgerd, Chenyang Sun

`https://youtu.be/f1U8KgFg1cA`

Zeckendorf's Theorem states that every positive integer can be written uniquely as the sum of non-consecutive Fibonacci numbers. We extend the result to a general class of linear recurrence sequences by developing the Zeroing Algorithm, a powerful helper tool for analyzing the behavior of such sequences.

▷ Folded Ribbon Knots and Ribbonlength

Troy Larsen, John Carr Haden

`https://youtu.be/vH5IIPE-B_g`

We study Kauffman's model of folded ribbon knots: knots made of a thin strip of paper folded flat in the plane. The folded ribbonlength is the length to width ratio of such a ribbon knot. Our research investigates the minimal ribbonlength for various families of knots; namely, torus, twist, pretzel, and rational knots.

▷ Baseball players : Underpaid, Overpaid, or Fairly paid for what they bring in?

Jerry Kye Potter

`https://youtu.be/cXr_mU8qdK0`

I look at baseball players and think, "Man, do I wish I were in their shoes." The problem with that is that they are some big shoes to fill and most of the time they do not get paid what they deserve or they get overpaid by a ridiculous amount. This presentation will shed some light onto why they are paid these wages.

▷ Meganball: Shooting Analytics for Division III Women's Basketball

Megan Wheeler

`https://youtu.be/d0NFwNqCttY`

This talk will discuss my research on expected points in division III women's basketball, specifically regarding the Old Dominion Athletic Conference, ODAC. The research is composed of three main goals. The initial goal was to develop a formula for the probability of making a basketball shot given various parameters. This formula was intended to provide meaningful new metrics for evaluating shot selection and shot efficiency for women's players and coaches. The data was collected from 60+ ODAC women's basketball games

from the 2017-2018 season and collected a set of over 10,000+ shots with court location and other factors including defensive pressure (closely guarded or not), dribble versus catch-and-shoot, end of shot clock, fast break, off the rebound, home/away, and whether the shooter was fouled. The data was collected by using the Roanoke College Stat Crew basketball app. The second goal was to rank players from the 2017-2018 season based on three categories: shot selection, expected points, hot shooting. Each team has a list with variables including player number, number of shots, number of shots made, points from shots (including free throws after being fouled but not free throws for common fouls over the limit), and expected points (computed using the formula from our model). We pulled out all players with at least 50 shots from the 2017-2018 season. The final goal was to discover which statistic predicts the winners the best in individual games. The predictors analyzed include shots, free throws, expected points, shot selection, hot shooting, and field goal percentage.

▷ Graph Scattering Transform

Rebecca Gjini, Mason Nakamura, Sam Smith, Emily Thompson

`https://youtu.be/vtbLTZ_SraI`

Deep multilayered networks have successfully applied to a variety of machine learning tasks. In particular, Convolutional Neural Networks (CNNs) attain state-of-the-art performance in many tasks such as image classification. The scattering transform is a mathematical model of these CNNs which allows the use of predefined wavelet filters. We apply a variation of the scattering transform to the task of graph classification. The scattering transform produces a sequence of coefficients at each layer of the network which can be used to classify different classes of graph data. Specifically, we use the scattering transform to classify different models of random graphs. We also reproduce and improve upon the results of Gao, Wolf, and Hirn (2019) on social network data. In addition, we explore the use of principal component analysis, applied to the scattering coefficients, as a dimensionality-reduction and visualization tool. Finally, we use Numba, a high-performance compiler, to improve the running time of our implementation.

▷ Filling in Missing Entries in a Matrix

Megan Gunn

`https://youtu.be/aHD518FOPXQ`

We explore missing matrix entries. We first develop methods for recovering a single missing entry in rank 1 and 2 matrices using known entries. We consider truly lower rank matrices and matrices with noise. We also note the application of the rank 2 method to higher rank matrices and matrices with

2+ missing entries.

▷ Numerical Analysis of the Parabolic Optimal Transport Problem

Abigail Brauer, Megan Krawick, Manuel Santana

`https://youtu.be/5x9HXibQG44`

We investigate a numerical algorithm for computing optimal transport maps in 1-dimension. Specifically, we use a finite-difference scheme to solve the time-dependent optimal transport problem and carry out an error analysis of the scheme. A collection of numerical examples is also presented and discussed.

▷ A Cyclic Variant of the Erdos-Szekeres Theorem

Jamie Schmidt, Alexander Seitsema

`https://youtu.be/jowAKc2JhqM`

We will discuss the Erdos-Szekeres Theorem concerning the occurrences of increasing and decreasing subsequences in a linear permutation. We will then state and prove a variant we have found for cyclic permutations.

▷ Radiative transfer modeling: Applications in astronomy and astrophysics

Colette Levens

`https://youtu.be/OVRirEvaZEI`

In this project, I studied the first single white dwarf to have recorded data of excess infrared emission from the dust disk around the white dwarf, G29-38. I used a radiative transfer modeling program called RADMC-3D to make a model that best fits the infrared spectrum data we have from G29-38's dust disk. I will introduce the premise of the project, describe the observed data that I used to create my robust model, go into the model setup, and finally, I will discuss how I evaluate the accuracy of the models I created.