TALKS

Jacob Austin, Kaylee Grabarkewitz, and Katlyn York (Simpson College)
Light Scattering Off Nanoparticles (Talk)
We present an experimental method to dynamically determine the composition, in terms of shape and size, of a mixture of nanoparticles suspended in water. This method is based on the use of the Discrete Dipole Approximation (DDA) to predict the scattering pattern of light incident on the sample. In this report we present a general background to light scattering, including Maxwell's equations, Stokes vectors, and cross sections. The theory of the DDA is reviewed and applied to shapes constructed of silver nanocubes. We give examples of the application of this method to various sample types and discuss applications and limitations. Theoretical results are then compared to experimental data.

Elijah Beed and Alex Kerr (Nebraska Wesleyan University)
Coloring the Uncolorable (Talk)
A proper coloring of a graph is an assignment of colors to the vertices in such a way that adjacent vertices receive different colors. Determining the number of proper colorings of a graph using only elementary counting methods often results in a hopeless mess of cases. The deletion-contraction recurrence breaks the problem down into one involving two simpler graphs, but this causes a combinatorial explosion in bigger graphs. We introduce an extension to the deletion-contraction recurrence that allows deletion of as many edges as needed simultaneously, thereby significantly reducing the depth of recursion.

Libby Farrell (Grinnell College)
When Are Two Things the Same? An Introduction to Category Theory (Talk)
Questions about sameness come up a lot in math. When are two graphs the same? When are two groups the same? When are two topological spaces the same? We will use category theory to answer the more abstract question of "When are two things the same?" in mathematics and to solve problems about sameness in math.

Jose Garcia, Jessica Longo, Matt Phad, and Page Wilson (Grand Valley State University)
Stirling Numbers for Sunflower Graphs (Talk)
A Stirling number of the second kind is the number of ways to take n distinct elements from a set and put them into k subsets, so that the subsets are non-empty and pairwise disjoint. To get the graphical Stirling number for a graph G, we add the restriction that any two vertices that are adjacent in G cannot be in the same subset. The traditional Stirling numbers of the second kind are the graphical Stirling number where the graph is empty. We explore Stirling numbers for sunflower graphs, which are powers of paths joined at a single vertex. We use the relationship between the number of proper colorings of a graph and the Stirling number for a graph to find the Stirling number for a sunflower graph.

Addison Grant (Simpson College)
Madness of Mathematics: An Analysis of Mathematicians in Theatrical Works (Talk)
To those outside of the academic world of mathematics, the work we do may seem like gibberish, or "a monkey at a typewriter." Perhaps the insanity of Georg Cantor's work has influenced this perception of mathematicians. I claim that the mathematicians featured in Proof, Arcadia, and The Curious Incident of the Dog in the Night time play into the stereotype of mad mathematicians while instilling the distinct notion that mathematics is more than nonsensical numbers.

Malia Jansen (Simpson College)
Classifying Diagonal knots (Talk)
Within the field of knot theory, grid diagrams are an alternative way to represent knots and links. Diagonal grid diagrams are of special interest in my research, specifically what kinds of knots can be represented on a diagonal grid diagram. I focus on one knot in particular in an effort to understand what makes a knot diagonal.

Lydia Magalhães (Simpson College)
Teaching Proof Writing Through Crochet (Talk)
For many high school students, the geometry classroom is the first place they are asked to engage in mathematical writing. The dreaded proof becomes the bane of many high schoolers math education. However, that does not need to be the case. One of the primary reasons that students struggle with proof writing

is because it is totally foreign to them. If they had prior or similar experience with this type of writing, they could be more successful. This research examines how crocheting can be used to teach students the mechanics of proof writing. By asking students to create a crochet square and then write their pattern as a proof, they gain experience with mathematical writing. This happens in a concrete and physical way making the learning more salient for students. This provides students with a framework to build on when learning about proof writing. Additionally, fiber arts are often used in mathematics and math classrooms. This research will explore those foundations as well as examine the effect of using crochet to teach proof writing.

Emily Montelius (Coe College)
Fault free tileability of rectangles, cylinders, tori, and Mobius strips with dominoes (Talk)
We study fault-free tileability of boards with dominoes as tiles, where the boards are rectangles, cylinders, tori, and Mobius strips. A tiling is a way of arranging pieces on a board, such that there is no space left uncovered, nor any space covered by more than one tile. To be fault-free every line that intersects the tiling must also intersect the interior of at least one of the tiles. We have complete results for cylinders and tori.

Kristina Smith (Simpson College)
Quantum Chromodynamics on the Lattice (Talk)
Quantum chromodynamics (QCD) describes the internal structure of subatomic particles like protons and neutrons. An interesting and challenging property of QCD is that because of the strength of the interactions within this theory, conventional perturbative methods provide a limited view of the scope of the theory. One method that bypasses this difficulty is to produce numerical simulations of QCD by using a discretized version of 4-dimensional spacetime called the lattice. In this project, I implement a version of the Metropolis-Hastings algorithm to measure the energy of two QCD-interacting particles. My results reproduce a known fact which is unique to QCD: that the energy between two particles grows linearly with the distance. This result explains one of the most striking observed features of QCD: color confinement, which is the fact that all QCD-interacting particles are confined within bound states like the protons and neutrons.

Aisha Washington (Iowa State University)
A simulation-based test for evaluating normality in high-dimensional samples (Talk)
The assumption of normality is a cornerstone to statistical inference that justifies concepts from simple linear regression up to more advanced statistical techniques. However it is difficult to determine normality in multidimensional samples. We developed a simulation-based test following Cramers theory that $\mathbf{X}$ is multivariate normally distributed if and only if every non-null linear projection is univariate normal. Using many simulations, we evaluate the rejection rates of our method and two current tests for multivariate normality, the generalized Shapiro and Energy tests. We found that our testing method is among the most powerful while also being computationally feasible.

Mikala Williams-Yee (Simpson College)
Critical Locations in Chemical Transportation Road Mapping: A Graph Theory Application (Talk)
Chemical hazardous material (hazmat) transportation has only recently become a focus for public and environmental safety. This project attempts to use a graph theory application generally used for terrorist attacks and natural disasters to model current hazmat transportation within the Des Moines Metropolitan Statistical Area with a unique approach not previously analyzed. The graph theory application involves finding critical highways necessary for transportation using a concept of betweenness to improve accuracy of critical locations and refine transportation routes to eradicate potentially dangerous situations before they occur.

POSTERS

Graham Brooks, Levi Lefebure, and Mason Remington (Simpson College)
Counting Sheep: Why Sleep Apnea is a Real Problem to Individuals with Down Syndrome (Poster)
Down syndrome Disintegrative Disorder (DSDD) is newly emerging in clinical literature. Most of the studies, however, only focus on the appearance of this disorder, and not the etiology. Our objective is to explore the relationship between sleep apnea and DSDD. A survey monkey survey was emailed out to patients at Massachusetts General Hospital's Down syndrome (DS) clinic and posted on Facebook. The survey gathered mostly qualitative data with yes/no, multiple choice, and open-ended questions. Of the 191 respondents (27%), 115 were aged 10-35. These are the ages where DSDD is commonly diagnosed. For these two groups, we saw a statistically significant difference in the number of hospitalizations, whether or not they have regressed, and their mean age of regression.

Mackenzie Finnegan (Simpson College)
Topological Data Analysis and Persistent Homology to show spacial Sorting in Animal Groups (Poster)
Homology is a tool used to look at the topological space and find the distinct features in any selected space. Fish move together in unique patterns that are very interesting to study, specifically the topology of the milling pattern fish tend to be in. The milling pattern is when fish swim in a school and the school is swimming in a circle. This can be accomplished by following Couzins model. This is done by starting with a point cloud of fish and slowly moving the data to finally achieve a CROCKER plot. The simplicial complex tells us what sort of interactions occur so we can create a persistent homology graph. From there the CROCKER plots can be created. CROCKER plots allow the reader to see important topological features in the group of fish. By examining a group of 100 fish after a period of time, a milling pattern was able to be found. It can be seen in the beta one CROCKER plot. There is a distinct area of yellow, which shows the fish were in fact milling. This satisfies the goal of the project which was to use topology, homology, and persistent diagrams to look at how schools of fish interact.

Lynn Huang (Iowa State University)
A Proposed Algorithm for Adjusted Kernel Linear Discriminant Analysis and Its Applications in Facial Recognition (Poster)
The current implementation of KLDA in R fails to compute projections in the case that the kernel matrix is non-invertible in the objective function. In this paper, we propose an algorithm for adjusted KLDA which allows for the approximation of singular matrices within KLDA's objective function, ensuring the success of computations for any set of tuning parameters. The validity of the algorithm is evaluated on several simulated datasets, then applied to three versions of a subset of the Morph-II dataset containing different extracted features for face imaging tasks. The transformed feature set is used to train several statistical classification models, whose performance is then evaluated to determine the efficacy of the algorithm.

Jacob Irwin (Simpson College)
Rubik's Magic: The Mathematical Wonders of the Magic Cube (Poster)
Each variant of a 3x3 Rubik's Cube is built upon the cubes preceding it, using many of the same algorithms to solve it. I will present how to solve several cubes, as well as prove how we know how many permutations are in some of these cubes.

Katheryn Menssen (Grinnell College)
Properties of Quadratic Anticommutative Hypercomplex Number Systems (Poster)
During my Summer MAP, I studied a type of Hypercomplex numbers which I call Quadratic Anticommutative Hypercomplex Numbers. Roughly defined, Hypercomplex numbers are numbers of the form x1 + i1x2 + + inxn+1 such that x1 + i1x2 + + inxn+1 = y1 + i1y2 + + inyn+1 if and only if xj = yj for all j in 1,2,,n. I define a quadratic anticommutative hypercomplex number system as a set of hypercomplex numbers x1 + i1x2 + + inxn+1 such that ij2 = pj for all j (where pj is a real number) and ijik = - ikij for all k not equal to j. These numbers have some interesting properties. In particular, I was able to prove a generalized form of the Demoivres formula for these numbers, and determine certain conditions required for a function on a Quadratic Anticommutative Hypercomplex plane to be analyticincluding generalizations of the Cauchy-Riemann equations.

Drew Roen (Simpson College)

Developing an Intuitive Rubik's Cube Solver (Poster)

The Rubik's Cube is arguably one of the most recognizable puzzles. With computer programs, it has become relatively easy to generate quick and easy solutions to any scrambled Rubik's Cube. These results are generally the simplest and most efficient methods, taking between 20 and 25 turns to solve a scrambled Rubik's Cube. The result is a lack of learning, making it highly unlikely a user would be able to go back and solve a different scrambled Rubik's Cube without assistance.

For my computer science and mathematics capstone, I have developed a web application that intuitively solves a Rubik's Cube. This application takes a user-inputted Rubik's Cube and gives guided directions on the easiest way to solve a Rubik's Cube. While the solution is significantly inefficient compared to other solving applications, mine is focused on helping the user learn to solve a Rubik's Cube.