FEBRUARY 25, 2023 GOLDEN POSTERS

Determining Highest Weight Matrices in a Crystal of Type A_{n-1}

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Advisor Dr. Tamsen McGinley

We present a method for determining whether a given $r \times c$ matrix M with nonnegative integer entries represents a highest or lowest weight node in a crystal graph. We examine crystal graphs of type A_{n-1} and use the matrix representation of the nodes in the graph. Left multiplying a matrix $M \in M_{r\times c}$ by specific matrices A and B will produce D and G matrices (respectively) that can be used to determine by inspection if M is a highest or lowest weight matrix. We explicitly define the set of D and G matrices, and extend existing crystal graph component operations to them, such as performing crystal operators, conversions between a biword and D and G, and constructing a D matrix from a G matrix (and vice versa). We also define the concepts of *rotation* ($\curvearrowright$) and *right upper triangularity* for these matrices. Through the use of these, we present two major theorems for identifying if a particular M is highest (lowest) weight based on the qualities of its D and/or G matrices.

One Hundred and One Arabian Carpets

Gregory Leathrum,Elijah Guptil & Daniel Sebo Cal Poly San Luis Obispo

Advisor Dr. Sean Watson

We used Dr. M. L. Lapidus's Fractal Zeta function, $\zeta_A(s) = \int_{A_\delta} d(x, A)^{s-N}\, dx$, to analyze the complex dimensions of components in 100 different modifications of the Sierpiński Carpet fractal construction under the Max and Euclidean Metrics. We developed a Semi-General Counting Method to count the different structures that appear in each iteration of the construction, which allowed us to compute the complex dimensions of 68 of these fractals.

Mathematical Modeling of Honeybee Colonies Infested with Mites and Virus

Pablo Curiel CSU Chico

Advisor Dr. Thomas Mattman

Using a mathematical model of a honeybee colony infested with mites and virus, sensitivity analysis is conducted to determine what parameters the model is most sensitive to. The model consists of a system of five first-order ordinary differential equations and was developed by Dr. Vardayani Ratti. The sensitivity analysis suggests that the model is most sensitive to variations in the max eclosion rate, natural death rates of healthy bees, the brood-maintenance coefficient, the rate of forager mortality due to homing failure, and the recruitment rate of hive bees to forager bees. Also, honeybees are highly dependent on temperature. The models current parameter values are based on seasonal averages. Extending the models parameters to match patterns in relevant climate data is currently taking place.

Modifying Kemeny's Constant

Connor Albright Sonoma State University

Advisor Dr. Kate Lorenzen, Linfield University

Kemenys constant can be thought of as the average number of steps in a random walk on a specific graph G needed to get from an arbitrary starting vertex to an arbitrary ending vertex. This is a good measure of the connectivity of G. We calculated Kemenys constant for a graph representing the board game Candyland, and investigated ways to change it. We further developed techniques to understand how Kemenys constant depends on the derivatives of eigenvalues and we calculated these derivatives for some families of graphs. We established bounds on the derivatives of eigenvalues for the normalized Laplacian, as well as the derivative of Kemenys constant. *This work is joint with Ari Holcombe Pomerance of Macalester College, Abigail K. Nix of Middlebury College, & Kimberly P. Hadaway and Joel Jeffries both of Iowa State University.*

The Graph of Minimal Cap Number 2

Matt Pablo and Xinliang Philong CSU Chico

Advisor Dr. Thomas Mattman

An important characterization of planar graphs is Kuratowskis Theorem, which states that a graph is planar if and only if it contains no K5 or K3 subgraphs. A graph G is called *apex* if it is planar plus a vertex. In other words, either G is planar, or there is a vertex v such that deleting v (and its edges) leaves a planar graph. It is known that there is a Kuratowski-type theorem for apex graphs: A graph is apex if and only if it contains no graph in L, where L is the list of so called *apex obstructions*. Although we know there is such a finite list L, researchers have not yet completely determined the list. In this project, we will classify the cap 1 obstructions of connectivity 2 for this portion of the list.

The Most Efficient Way to Contain a Virus with Limited Vaccinations

Andrea Barnett CSU Chico

Advisor Dr. Thomas Mattman

We have recently experienced the pandemic of COVID, and know how a biological virus can spread globally in a matter of months. Initially vaccinations were in scant supply, raising the question of how to quickly contain a virus with limited vaccinations. Using the previous models of Moeller and Wang, Hartke, Messenger, and Fogarty, we endeavor to find the most efficient use of vaccinations to contain a viral spread. We focus on an irregular pentagon graph and a regular hexagon grid. The pentagon will have vertices with degrees of three and four. In contrast the hexagon is regular with all vertices having degree 6. We create different simulations where the initial disease is placed at various vertices on these graphs. *This is joint work with Anthony Macias ,Ely Schoenfield, Marco Ocampo and Medardo Perez also of CSU Chico.*

Introduction to Differential Equations and SIR Epidemiological Modeling

Jorge Reyes, University of Nevada Las Vegas

Advisor Dr. Monika Neda

In the last few years, Covid-19 has taken the lives of too many people. Therefore, it is essential to study how we can model these phenomena with mathematical equations for future forecasting. To that aim, this study is about spreading diseases, such as Covid and Monkeypox. We used a classical system of differential equations and the so-called SIR (Susceptible Infected and Recovered) model to describe the behavior of these epidemiological diseases. The model was solved numerically and function behavior for Susceptible, Infected and Recovered populations are presented for various parameter values.

Examining the Correlations between COVID-19 Death and Vaccination Rates and the Elderly Dependency Ratio for Various Countries

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Advisor Professor Xiaoyan Liu of the University of La Verne

With its strong transmission ability, the Covid-19 virus has affected billions of people around the globe. It is important to recognize what factors affect the mortality rate for those infected individuals. Using the Covid-19 death rate per million (DRPM), we are able to hypothesize a negative correlation with vaccination rates, a positive correlation with elderly dependency, and a negative correlation with hospital beds per 10,000 people and the DRPM. Our group first found data charts on CIA, ChartBin, and Worldometer. To test our hypothesis, we collected data for the factors aforementioned from the countries with the highest DRPM. Peru and Bulgaria had the highest COVID-19 DRPM. We use a variety of plots to present the results of these significance tests.

Investigating the Correlations between COVID-19 Death and Vaccination rates of US states

Yiming Wang Texas A&M, Wenyi Ouyang Shenzhen College of International Education, and Else Yaxuan & Elsa Yang of Millburn High School NJ

Advisor Professor Xiaoyan Liu of the University of La Verne

Ever since 2020, the COVID-19 virus has greatly impacted our lives. We examine relationships between COVID mortality rates, vaccination rates, the elderly dependency ratio, and physician accessibility in the fifty US states. The data were collected from a wide array of reliable online sources, such as the official websites of the CDC and the WHO. Using linear regression, we found a negative correlation between the COVID death and vaccination rates, and between death rates and physician availability. In contrast, there is a strong positive correlation between the elderly dependency rate and the COVID-19 death rate.