Abstracts

Invited Talk: "A Primer on Deep Learning for Mathematicians"
Dr. Scott Simmons, Drury University

Advances in computational power are usually met with applications that have been waiting in the wings and that are ready to push newly available hardware to its extremes. And so it was in the aughts when the proliferation of affordable GPUs found researchers in possession of exceedingly large corpora of raw information and searching for new ways to learn from those data.

The resulting resurgence of neural networks has been dominated by Deep Learning, which has revolutionized performance on tasks such as machine translation and image classification. In the 90s, many believed deep neural networks to be computationally infeasible. However, courtesy of massive but artfully implemented applications of the chain rule, deep networks are not only viable in modern times but often lead to uncommonly elegant solutions.

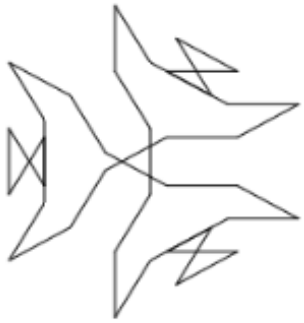
After a brief introduction to neural networks, we will survey two deep learning architectures that have proven useful in the 2010s; namely, convolutional and recurrent networks. This is an introductory talk requiring no prior knowledge of deep learning, but one that does not minimize the underlying mathematics. Time permitting, recent advances by applied mathematicians in the area of machine/deep learning will be discussed.

"The Number of Cyclic Subgroups of a Group: A Brief Introduction"
Jamie Chavez Malacara, Missouri State University
Faculty Mentors: Dr. Richard Belshoff, Missouri State University, Dr. Les Reid, Missouri State University

Groups are very important in both pure and applied math. For example, groups can be used to capture and study the fundamental nature of symmetry. While a lot is known about groups and their properties—for instance, all finite simple groups have been classified—there are still many unanswered questions regarding groups with certain properties. This talk will be expository in nature, building up from defining a group to shedding some light on what is known about groups with a specific number of cyclic subgroups, concluding with brief remarks about our preliminary findings.

"An Algebraic Introduction to Turtle Geometry"
Jordon Daugherty, Missouri State University

Turtle programming is a group of programming languages that are often used to introduce computer concepts to children via giving instructions to a "turtle" of where they should go. Several such languages exist including LOGO, KTurtle, and Pyturtle, but they all have a few commands in common, forward, backward, turn left or right, and repeat. Even though these languages were intended for children, they conceal some surprisingly deep underlying math that has been, to my knowledge, barely explored. Specifically, I focus my attention on loops where each iteration the turtle turns an amount determined by a polynomial. My intent is to introduce some questions I asked while playing with turtle programming and then some techniques to possibly solve some of these questions which are: will the path be closed, when is it closed, and how many iterations does it take before the pattern repeats itself?



Path traced by $f(x)=30x^2-30x+30$

"Tiling Punctured Checkerboards"
Ethan Lynch, Missouri State University
Faculty Mentor, Dr. Les Reid, Missouri State University

A classic problem in recreational mathematics asks if an 8×8 checkerboard with diagonally opposite corners removed can be tiled by dominoes (the answer, as we will see in this talk, is "no"). A punctured checkerboard is an $m\times n$ rectangular array with one or more squares removed. We investigate under what conditions a punctured checkerboard can be tiled with $1\times a$ rectangles. Using the techniques developed, we will solve a problem recently posed in the journal *Crux Mathematicorum*. Time permitting, we will also discuss tiling punctured $\ell\times m\times n$ arrays.

"The Periodic Behavior of a Class of Functions Modulo N"
Jake Miles, Missouri State University
Faculty Mentor: Dr. Les Reid, Missouri State University

In this talk, we examine functions $f:\mathbb{N}\to\mathbb{Z}_n$ of the form $f(x)=\mathrm{mod}\left(p(x)a^x,n\right)$, where $p(x)$ is a polynomial with integer coefficients and *a* is a non-zero integer. One can show that these functions are periodic and we wish to investigate their period. For example, the function $f(x)=\mathrm{mod}\left(x2^x,3\right)$ has values 0,2,2,0,1,1,0,2,2,0,1,1,…which has period 6. We will first study polynomial functions ($a=1$), giving a complete answer for linear polynomials and partial results for higher-degree polynomials. We then study exponential functions and end with an investigation of the general case.

“Lie Theory: An Introduction and Historical Analysis”
Montana Miller, Missouri State University
Faculty Mentor: Dr. Samuel Chamberlin, Park University

Lie theory is the study of Lie groups and their associated Lie algebras. The discovery of such algebraic objects is due to Norwegian mathematician Sophus Lie during the mid-1800s. In this presentation, we explore the motivation behind Lie’s ideas which were largely inspired by the work of Evariste Galois. We then introduce the notion of a Lie algebra, followed by an investigation of the matrix Lie algebra $\mathfrak{sl}_2$.

“Using Machine Learning and Math to Assess Stroke Patient Recovery”
Carter Sifferman, Drury University
Faculty Mentor: Dr. Marjorie Skubic, University of Missouri, Columbia

Stroke is a leading cause of long-term adult disability. Many stroke patients participate in rehabilitation programs prescribed by an occupational therapist to aid in recovery; however, occupational therapists rely on in-clinic assessments and often-unreliable self-assessments at home to track a patient’s progress, limiting their ability to monitor how patients perform outside of a clinical setting. To alleviate this problem, we propose a self-contained system that records depth images within a stroke patient's home. The system then uses machine learning to classify the actions it sees the patient performing. Once actions are classified, movement metrics, such as efficiency and extent of reach, can be automatically extracted, and sent to an occupational therapist.