Fall 2018 MEGL Projects

Visit http://meglab.wikidot.com/ to apply.

Geometry of complex networks

Prof. Matt Holzer

The goal of this project is to study geometrical features of complex networks. The approach will be two sided. On one hand, we will construct networks by sampling manifolds and try to understand the relationship between features of the sampled manifold and properties of the created network. Reversing this process, we will try to reconstruct the manifold associated to a network and thereby discover the underlying geometry of the network.

Requires: Linear algebra. We will use Matlab or python. Interest in programming is essential, but experience is flexible.

Visualizing (Complex) Hyperbolic Geometry

Prof. Anton Lukyanenko

In this entry-level project, we will work to illustrate the geometry of non-Euclidean spaces using virtual reality goggles, 3D printers, and Unity and Mathematica software environments. We will start by recreating some previous illustrations in 2D (see my website's gallery), and then continue to explore new higher-dimensional objects in 3D and beyond.

Requires: Calculus 3, some programming experience and excitement to learn new math and new tools.

On the Equivariant K-theory of Flag varieties

Prof. Rebecca Goldin

There are several nice bases for the equivariant K-theory of flag varieties, but it is not clear how to change bases. This project involves permutations (cool, elementary!) and line bundles and geometry.

Requires: Math290. Preferred: Abstract Algebra, Python, SimPy.

Attacking Problems in Discrete Geometry Using Satisfiability Solvers

Prof. Walter Morris

Many problems in discrete geometry can be expressed in terms of the existence of a set of points in R^n satisfying a set of linear inequalities. For example, both the "happy end" problem and the "6-step conjecture" were solved using the same computer-enumeration technique. For the MEGL project, students will learn about *uniform chirotopes* and the *Grassman-Plucker condition*, and use these to attack variants of the above problems, with the goal of finding proofs that could be understood by humans.

Requires: Math290 and a programming course such as CS112 or Math203.

Arithmetic Dynamics on Moduli

Prof. Sean Lawton

This project continues the study of the dynamics of the outer automorphism group of a free group F on the finite field points of the space of representations of F. We are interested in two main problems: understanding the length of the largest orbit and which classes achieve it, and defining and proving the action is "ergodic" in this arithmetic setting. Additionally we are working on creating, in 3D print and VR, visualizations of these dynamical systems.

There has been some recent interest in this problem from other researchers and we have also been investing time in reading the work and methods of these other researchers.

Requires: Math290, Abstract Algebra preferred.

Geometric Flows and Dimension Reduction

Prof. Tyrus Berry

Use sample points on manifolds to approximate geometric operators and simulate geometric flows. Estimate optimal embeddings of manifolds into Euclidean spaces by representing the appropriate energy functionals and applying minimization methods from numerical analysis.

Requires: Advanced coursework including Math 446, and Matlab or Python.

Cooperative Parking for Self-Driving Cars (Summer Project, apply directly.)

Profs. Anton Lukyanenko and Damoon Soudbakhsh

Imagine you have a garage packed full of self-driving cars and want to get one out. How should the other cars move around to release it? For this summer's project, we are looking for two to three undergraduate students to help with the first steps in answering this question: getting several FlockBot robots moving, setting up software for modeling and controlling the robots, and finding the right algorithms for planning their motion. The undergraduate students will join a team of two faculty members and two graduate students from mathematics and engineering departments.

Requires: Math 290 and some experience or coursework relevant to at least one of the above topics.

Join the MEGL community!

The Mason Experimental Geometry Lab, housed at L106 Exploratory Hall, involves undergraduate students, graduate students, and faculty in cutting-edge mathematics projects; and provides a research entry point for future mathematicians.

The facility provides computation and visualization equipment, including high-speed and high-memory computers, virtual reality environments, and 3D printers.

Each project (designated entry, intermediate, or advanced) runs for one semester, with the possibility of continuation.

Undergraduate MEGL members sign up for 3 credits of independent study credits and occasionally help run MEGL's community outreach at nearby schools.