Cool things I've done

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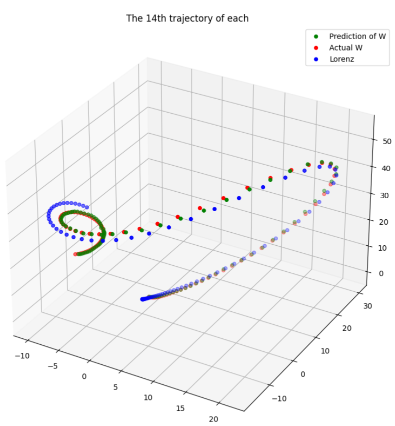
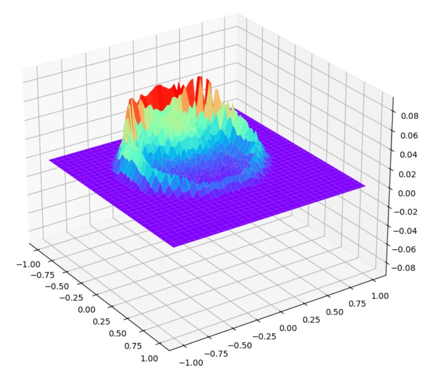
Fall 2021 - Making Computers Learn Physics

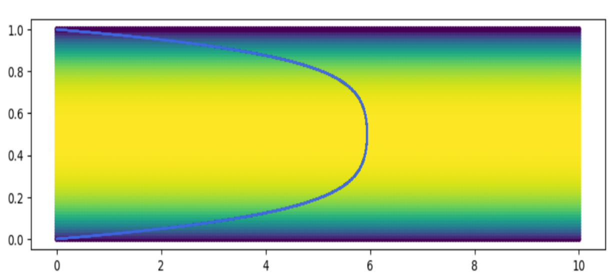
I have recently used Deep-ONets [Lu Lu] and physics-informed neural networks to approximate differential equations such as the 2D wave and heat equations, the Lorenz system of ODEs, Burgers equations, and gravity pendulums. The input to the network was typically generated via numerical integration, and the 2D wave equation was solved analytically via separation of variables. Dr. Tian also introduced me to a paper on Data Assimilation [Biswas UMBC], which we applied to the Lorenz system. This process gives rise to a new system that depends on the original system. The figure below (left) shows the Deep-ONet's prediction of the data assimilated Lorenz system. The next task on our list is to use Deep-ONets and Data Assimilation to approximate solutions to the Navier Stokes equations.

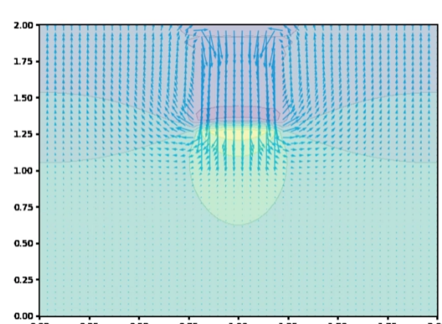




Spring 2021 - Partial Differential and Difference Equations

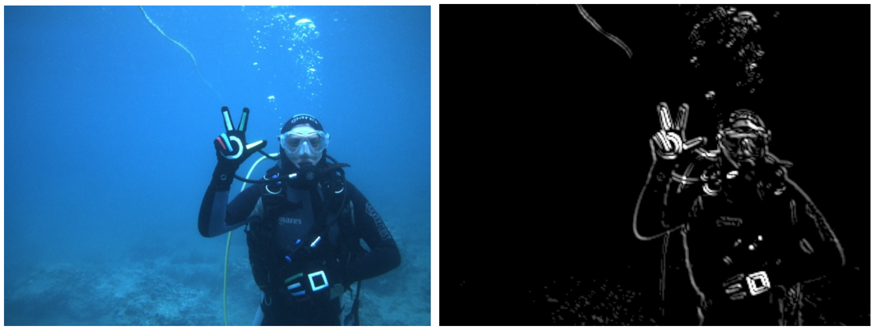
In the early semester, I gave a complete fifty-minute proof of the Maximum Principle, with the linked document being the exact presentation that I wrote out in class that day. It was this proof that led Dr. Tian to invite me to research with her. For the final project, I solved a simple case of the two-dimensional Navier Stokes equations, then modified and animated an existing FDM code, introducing an obstacle in the flow. This data will be used as input into the Deep-ONet in the following weeks. Of course, I have new plans for this data after Math 675.





2020 - Deep Learning and Self-Studying Engineering

Through the job search, and the job itself, I could never put down the math. In Dr. Cornwell's Deep Learning course, I made feed-forward, convolutional, and non-linear recurrent neural networks, all achieving very high accuracy. Prior to the course, I wrote a code that computed discrete 2D convolution in NumPy, yielding the figure below. I worked through an engineering textbook to prepare for problems in fluid mechanics.



2019 - Mathematical Modeling and Topology

In Mathematical Models with Dr. Gluck, my teammate and I simulated the spread of a disease through a population, as well as modeled the growth of certain species using proportionality relationships. I then used the proportionality approach on a similar problem for the International Mathematical Contest in Modeling, earning an Honorable Mention.

In Dr. Cornwell's Topology course, for my graduate project, I proved point-wise convergence of sequences in a topological space of functions. I used the result to prove continuity of the evaluation map.

2018 - Optimization and Differential Geometry

In Operations Research with Dr. Kolesnikov, I derived linear program that optimized delivery schedules, and wrote a primitive Mathematica code to solve the program.

After Dr. Zimmerman's Differential Geometry course, I wrote Mathematica code which plotted a surface, placed a point on the surface, and displayed the tangent plane at that point. The point could be dragged throughout the surface, and the tangent plane followed suit. Later days brought about a tragic accident involving the recycling bin.