MICHAEL MOY

Colorado State University Department of Mathematics

EDUCATION

Colorado State University
PhD student in the Department of Mathematics — *Expected graduation: August 2023*
MS in Mathematics — *May 2021*
Advisor: Henry Adams
Graduate Teaching Assistantship: fall 2019 to fall 2022
Graduate Research Assistantship: spring 2023
GPA: 4.000

Yale University
Master of Music — *May 2019*
Coursework in math and data science
GPA: 4.000

University of Colorado at Boulder
BS in Applied Mathematics (mechanical engineering focus) — *May 2016*
Bachelor of Music — *May 2016*
GPA: 3.894

Loveland High School — *May 2011*
International Baccalaureate Diploma Program

WORK EXPERIENCE

NASA Internship (SCaN Internship Project) — June 2022 - September 2022
Intern — *Remote internship — Glenn Research Center, Cleveland, OH*

This internship focused on the mathematical modeling of networks that vary over time, with the goal of improving the understanding of networking in space. It built on projects from the previous two years (see below). One of the main projects was the implementation and further theoretical development of an improved routing algorithm I proposed in 2021. This work will be described in a paper [11] in the following year, and the work on the algorithm is continuing as part of NASA's High Rate Delay Tolerant Networking project. I also continued a project of modeling networking with mathematical tools called sheaves, resulting in the paper [9].

NASA Internship (SCaN Internship Project) — June 2021 - August 2021
Intern — *Remote internship — Glenn Research Center, Cleveland, OH*

This internship focused on mathematical techniques for modeling networking in space. The techniques centered around tools from the field of applied topology or topological data analysis, and in particular we used techniques from applied sheaf theory, building upon work from the previous year; see [10] below. I also worked on an improvement to a routing algorithm proposed for space networks called Contact Graph Routing [7]; there is still current work further developing this project.

NASA Internship (SCaN Internship Project) — June 2020 - August 2020
Intern — *Remote internship — Glenn Research Center, Cleveland, OH*

This internship considered applications of topology and abstract algebra to machine learning, specifically neural networks, and to networking, supporting the goal of modeling networking in space. I worked with another intern to analyze neural networks using techniques from topological data analysis;

see [4] below. Along with a group of interns, I investigated a mathematical framework for routing algorithms in the language of applied sheaf theory, contributing to papers [1] and [6] below.

Air Force Research Laboratory Scholars Program May 2019 - August 2019
Intern *Albuquerque, NM*

The goal of this internship was to examine the possibility of placing sensors in geosynchronous orbit to observe small orbital debris. As the sole intern on this project, my responsibilities ranged from understanding the current state of research on orbital debris to mathematical modeling and writing simulations in MATLAB. I produced code to model the debris population and the effectiveness of sensors, resulting in estimates of the ideal position of sensors and implications for sensor designs.

PAPERS AND PREPRINTS

My research is in the area of applied topology or topological data analysis (TDA). My advisor, Henry Adams, and I wrote a survey paper [3] on applications of TDA, focusing on applications to machine learning. Similarly, my 2020 internship at NASA considered using TDA to study neural networks [4]. My three internships at NASA included projects focused on applications of sheaves to networking; see [6], [9], [10] and arXiv preprint [1]. My 2021 and 2022 internships also included work that improved an algorithm for routing in space called Contact Graph Routing [7], [11]. My master's thesis [5] focuses on a theoretical topic in applied topology, providing the first proof of the stability of persistent homology for important types of metric thickenings. Extensions of this result will be in an upcoming paper; a preprint [2] is available. My recent work in [8] proves new results about metric thickenings as well, answering an open question in this area.

[1] M. Moy, R. Cardona, R. Green, J. Cleveland, A. Hylton, and R. Short, "Path Optimization Sheaves," *arXiv e-prints*, Dec. 2020. arXiv: 2012.05974 [cs.NI].

[2] H. Adams, F. Mémoli, M. Moy, and Q. Wang, "The Persistent Topology of Optimal Transport Based Metric Thickenings," *arXiv e-prints*, Sep. 2021. arXiv: 2109.15061 [math.MG].

[3] H. Adams and M. Moy, "Topology applied to machine learning: From global to local," *Frontiers in Artificial Intelligence*, vol. 4, p. 54, May 2021, ISSN: 2624-8212. DOI: 10.3389/frai.2021.668302. [Online]. Available: https://www.frontiersin.org/article/10.3389/frai.2021.668302.

[4] A. Hylton, I. Lim, M. Moy, and R. Short, "Interpreting a topological measure of complexity for decision boundaries," presented by Ian Lim at ASMDA 2021, accepted for publication in upcoming conference proceedings, Jun. 2021.

[5] M. Moy, "Persistence stability for metric thickenings," M.S. thesis, Colorado State University, Mar. 2021. [Online]. Available: https://mountainscholar.org/handle/10217/232524.

[6] R. Short, A. Hylton, R. Cardona, R. Green, G. Bainbridge, M. Moy, and J. Cleveland, "Towards sheaf theoretic analyses for delay tolerant networking," in *2021 IEEE Aerospace Conference (50100)*, 2021, pp. 1–9. DOI: 10.1109/AERO50100.2021.9438167.

[7] A. Hylton, R. Short, J. Cleveland, O. Freides, Z. Memon, R. Cardona, R. Green, J. Curry, S. Gopalakrishnan, D. V. Dabke, B. Story, M. Moy, and B. Mallery, "A survey of mathematical structures for lunar networks," in *2022 IEEE Aerospace Conference*, 2022.

[8] M. Moy, "Vietoris-Rips Metric Thickenings of the Circle," *arXiv e-prints*, Jun. 2022. arXiv: 2206.03539 [math.AT].

[9] R. Short, J. Cleveland, Z. Cooperband, and M. Moy, "On the current state of sheaf theoretic networking," in *IEEE WISEE 2022*, 2022.

[10] R. Short, A. Hylton, J. Cleveland, M. Moy, R. Cardona, R. Green, J. Curry, B. Mallery, G. Bainbridge, and Z. Memon, "Sheaf theoretic models for routing in delay tolerant networks," in *2022 IEEE Aerospace Conference*, 2022.

[11] R. Short, J. Cleveland, M. Moy, Y. Kirkpatrick, and D. Conricode, "Contact multigraph routing: Overview and implementation," abstract accepted to the 2023 IEEE Aerospace conference, 2023.

TEACHING EXPERIENCE

Graduate Teaching Assistant at CSU Fall 2019 - present

- I am currently an assistant for a graduate course in real analysis (advanced calculus) and also hold office hours for various calculus classes.
- I taught sections of calculus 2 from fall 2020 to spring 2022. During the 2020-2021 academic year, teaching was both in-person and remote.
- I was an assistant for a calculus 3 course during the 2019-2020 academic year. Responsibilities included working with students during lectures, office hours, and grading.
- In the fall of 2021, I contributed to a textbook being written primarily by a CSU professor for a new math course for computer scientists. I wrote examples for sections on set theory, discrete math, sequences, and series.

Undergraduate Learning Assistant at CU Boulder Fall 2014 and Fall 2015

- I was an assistant for an undergraduate real analysis (advanced calculus) course for two semesters during my undergraduate. This included office hours and grading.

SCHOLARSHIPS

- CU Boulder College of Engineering 4-year scholarship
- CU Boulder College of Music 4-year scholarship
- Yale School of Music Full Tuition Award and Fellowship

CODING ABILITY

- Languages: Python, MATLAB, R
- MATLAB experience: my internship in 2019 centered around modeling of orbital debris in MATLAB.
- Python experience: during my internship in 2020, we used Python along with libraries TensorFlow and Scikit-TDA to analyze neural networks. During my 2021 internship, I implemented my improved Contact Graph Routing algorithm in Python to make experimental comparisons to the previous algorithm.