

The robustness of a mathematical method determines its utility. Just imagine designing a communication network that fails to account for topological perturbations, or modeling an epidemic with strictly deterministic differential equations. My goal, then, is to research robust methods in algebraic topology that can be applied in both abstract and computational settings.

For example, consider training an AI to distinguish the tone signature of different musical instruments. Applying persistent homology, we associate “holes” in an audio recording’s time-delay phase-space with a sample statistic: the persistent rank function (PRF). Corresponding informally with Nikki Sanderson [1], I learned a computer trained on PRFs more accurately classifies tones than one trained on Fast Fourier Transforms. Here a topological invariant answers the question “which instrument?” with higher fidelity than a recording’s frequency transform.

My research interest stems from my exposure to homotopy theory as an undergraduate, my grounding in point-set topology, and insight from two years of service work since graduating.

Advised by Dr. Jonny Comes, my senior independent study examined how Galois theory constrains the solution space of Fuchsian-type differential equations. Following Michio Kuga, we developed a correspondence between the fundamental group of $D = \mathbf{C} \setminus \{x_1, \dots, x_n\}$ and this surface’s universal covering space \tilde{D} . Exploiting the representation of the group of covering transformations $\Gamma(\tilde{D} \rightarrow \tilde{D})$ as a group of linear automorphisms, I parameterized solutions to the hypergeometric DE. For interesting cases, I found the monodromy representation at singular points, and generated plots. My conference poster [2] summarizes our method, its history, and discusses applications to mathematical physics. At the same time, I studied point-set topology under Dr. Dave Rosoff, who led a seminar in the Moore method. I reasoned from counter examples, occasionally contributing a stronger hypothesis to our notes to account for spaces not so well behaved. We had enough time to abstract spaces to objects and maps to morphisms as a means of analogously introducing category theory from topology. I am enthusiastic to build from this ground to higher results, one of which I reached in my senior study, another of which Nikki Sanderson demonstrated ahead of me.

After graduating, I took two years to perform stipended service work. In Houston, under Shaoli Bhadra, I developed scalable [resources](#) for refugee case management, which included crowd-sourcing a [map of clinics and languages spoken](#) through the Google Maps API. I wrote bug reports for the implementation three databases, and, when Texas cut funding for Refugee Medical Assistance, I contributed to a data management plan for the small refugee population transitioning from state to federal medical care. In Olympia, I am a community organizer at a 24/7 homeless shelter. I rely on distributed version control, and have therefore become a staunch advocate for “deploying early and often”. For example, I built [volunteer.fcscs.org](#) to host a schedule of events, but it now doubles as a wiki. As I have begun mentoring interns and work-study students who are preparing to embark on careers in social work, I am mindful to develop skill that will transfer neatly into a teaching assistantship. In all, I believe I have cultivated valuable habits for collaborative research, e.g., focusing my effort on tasks where I have a comparative advantage, surveying the field and working where others have left off, and keeping a transparent workflow by maintaining open notebooks.

My career aspiration, however, is to become a research mathematician, and to that end, I am ambitious to return to academia. To prepare for graduate study, I have enrolled in correspondence courses at the University of Idaho. I am also reading from Hatcher’s *Algebraic Topology*, referencing topics in Gower’s *Companion to Mathematics*, and “sharpening the saw” with UNIX, the Jupyter notebooks, and Hal Abelson’s *Structure and Interpretation of Computer Programs*.

While I am open to the breadth of mathematical inquiry at the University of Oregon, my experience manipulating homotopy groups and my topological intuition leads naturally towards algebraic topology—specifically homology and homotopy theory—with computational topology in mind for applications. I would be glad to collaborate with Profs Lipshitz, Dugger, Sadofsky, or Sinha. Having surveyed their teaching and recent publications on the arXiv, I believe that the doctoral program in Mathematics at the University of Oregon would be a great fit for my interests.

References

- [1] N. Sanderson, E. Shugerman, S. Molnar, J. D. Meiss, and E. Bradley, *Computational Topology Techniques for Characterizing Time-Series Data*, Sep. 2017. arXiv: [1708.09359](https://arxiv.org/abs/1708.09359).
- [2] C. Grainger, *Applications of Galois Theory*, College of Idaho 11th Student Research Conference, May 2016. [Online]. Available: <http://coltongrainger.com/docs/galois.pdf>.