Matthew Piekenbrock

(937) 269 8582 • matt.piekenbrock@gmail.com • mattpiekenbrock.com •

Education

Northeastern University (NEU) **2021-Present**
(Pursuing) PhD of Computer Science *GPA: 3.83*

Michigan State University (MSU) **2019-2021**
(Transferred) PhD of Comp. Mathematics, Science, and Engineering *GPA: 3.50*

Wright State University (WSU) **2015-2018**
Masters of Science in Computer Science *GPA: 3.83*
Bachelor of Science in Computer Science + Minor in Statistics *GPA: 3.42 (In-Major)*

Teaching Experience

- Teaching Assistant - Data Mining Techniques — CS 6220 / DS 5230, Summer 2023 (NEU)
- Teaching Assistant - Supervised Machine Learning — CS 6140/4420, Spring 2023 (NEU)
- Teaching Assistant (NEU) — Unsupervised Learning (DS 5230), Fall 2022
- Graduate Teaching Assistant (MSU) — Comp. Modeling & Data Analysis (CMSE 201), Fall 2020

Experience

Graduate Research Assistant **Fall 2019-Present (Graduating Summer 24)**
Northeastern University / Michigan State University *Graduate Student*

My PhD research focused on developing computationally tractable extensions of *Persistent Homology* in dynamic and multi-parameter settings, and in showing viable applications to problems such as periodic time series analysis, characterizing graph similarity, and n-D shape matching. Subsequent focused on topological dimensionality reduction using fiber bundle theory (see **tallem** in the **Open Source** section) and on spectral-relaxations of the persistent rank invariant, with applications to exploratory data analysis, .

LERCIP Intern **Summer 2022**
John H. Glenn Research Center at Lewis Field *National Aeronautics and Space Administration*

I was re-hired back at NASA as part of the Space Communications and Navigation (SCaN) program to expand the algorithmic theory necessary to have effective satellite communications in space environments. My research focused on incorporating additional geometric assumptions into routing models built for of delay- and disruption-tolerant networks, particularly in the low Earth orbit regime.

AI Research Associate **Fall 2018-Fall 2019, Fall 2017**
Air Force Research Laboratory *Oak Ridge Institute for Science and Education*

In a collaborative effort to foster new research frontiers in the area of Topology Data Analysis (TDA) between WSU and AFRL, I worked in a research group studying how to combine techniques from the field of topology and machine learning in both supervised and unsupervised settings. I primarily researched multi-scale extensions to the *Mapper* framework, an often used modality for performing TDA. The effort required developing a number of custom open source packages, such as the **Mapper** and **simplextree** packages (see the **Open Source** section).

LERCIP Intern **Summer 2018**
John H. Glenn Research Center at Lewis Field *National Aeronautics and Space Administration*

Towards accelerating materials discovery and design, I was hired by Dr. Steven Arnold (via the Multiscale Modeling Materials and Structures Division) to spend an extended internship at NASA using ML to infer multiscale structural properties from material stress-response data. The project involved deducing process-structure-property (PSP) relationships from a surrogate model trained on laminate stress-strain curve data generated via the Generalized Method of Cells via experimental design theory. My time was primarily spent:

- Learning basic micromechanics and lamination theory
- Architecting a feed-forward neural network (the surrogate model) to model laminate stress-response data
- Implementing a non-parametric information-theoretic estimator efficiently, proving its convergence rates, and modifying an MCMC-like optimization procedure (approximate coordinate exchange) to minimize it

A technical report and subsequent journal publication can be found on my CV. Presentation material, code, and all other material is available upon request for U.S. citizens only.

Graduate Research Assistant **2015 - 2018**

Wright State University *Machine Learning and Complex Systems Lab*

After a brief independent study, I began a graduate research assistantship (GRA) with the Machine Learning and Complex Systems lab studying the use of generative models for modeling macroscopic patterns of real-world traffic networks inferred from raw trajectory (e.g. GPS) data. Topic areas the project focused on included density based clustering, *temporal network models* (e.g. stochastic block models), and *trajectory mining*. Much of my research focused on ensuring the data-inferred networks were representative of the underlying movement data. Our solution involved using the *cluster tree*—a level-set shape characteristic of an estimated density function—to infer significant clusters of movement. This research was supported by the Center for Surveillance Research, a National Science Foundation I/UCRC.

Student Participant **Summer 2017**

Google Summer of Code 2017 *R Project for Statistical Computing / Google*

I submitted a successful funding proposal under the Google Summer of Code (GSOC) Initiative to the R Project for Statistical Computing to explore, develop, and unify developments related the theory of density-based clustering, namely the recent developments related to the cluster tree. This involved a variety of code development which culminated in the form of an R package, as well as research to further understand the theory and utility of the cluster tree. For more details, see the project page.[1]

Research Associate **2014 - 2016**

Air Force Institute of Technology *Oak Ridge Institute for Science and Education*

Towards the end of my undergraduate degree, my contract at AFIT was extended under ORISE, where I continued working with the same research group. During this time I primarily worked on the development of a novel Iterative Closest Point algorithm amenable to massive parallelization, implemented in C++/CUDA, for the purposes of enabling real-time tracking of aircraft in the context of Autonomous Aerial Refueling. Our solution involved pairing a cache-oblivious KD-tree search with a novel "Jump-and-Walk" closest-point search on a preprocessed Delaunay triangulation. The effort lead to multiple publications (see CV). I also worked on:

- Researching hierarchical markov model for predicting web navigation patterns
- Parallelizing existing atmospheric absorption routines with OpenCL
- Coding a nonlinear optimization algorithm in ANSI-C, and making it callable from MATLAB via MEX

Undergraduate Research Assistant **2013 - 2014**

Air Force Institute of Technology *Southwestern Ohio Council for Higher Education*

I was hired at the Air Force Institute of Technology (AFIT) as an undergraduate student to do research in a multi-disciplinary team called the Low Orbitals Radar and Electromagnetism group, where I worked on a diverse set of projects involving computational, statistical, or physics-based requirements. Being my first research-oriented experience, I either assisted graduate students with primarily programmatic or educational tasks or worked on very computationally-oriented tasks. Some example projects involved:

- Implementing an unsplittable flow approximation algorithm in C++ and Python
- Creating a conversion tool between Oracle's Abstract Data Type and XMLType
- A prototypical UI to to enhance searching and viewing of 2-or-3D models using JavaScript

Open Source Contributions

primate (python package) *Author* @ `[gh]/peekxc/primate`
dbscan (R package) *Coauthor* @ `[gh]/mhahsler/dbscan`
clustertree (R package) *Author* @ `[gh]/peekxc/clustertree`
Mapper (R package) *Author* @ `[gh]/peekxc/mapper`
simplextree (R / Python package) *Author* @ `[gh]/peekxc/simplextree-py`
tallem (python package) *Author* @ `[gh]/peekxc/tallem`

Awards, Extra Curricular, Misc.

Ginther Fellow: MSU 2019-2020

Outstanding Masters Student Award (Computer Science): WSU 2017-2018 academic year

Outstanding Position Paper Award: National Model United Nations Annual Conference (2014)

Outstanding Delegation Award: National Model United Nations Annual Conference (2013)

[1] `https://summerofcode.withgoogle.com/archive/2017/projects/5919718795902976/`