Matthew Piekenbrock Curriculum Vitae

(937) 269 8582 • matt.piekenbrock@gmail.com • wright.edu/∼piekenbrock.5

Education

GPA: 3.8 Overall, 4.0 In-Major

Wright State University **Dayton, OH**
Masters of Science in Computer Science *2018*

Wright State University **Dayton, OH**
Bachelor of Science in Computer Science, Minor in Statistics *2015*

Relevant Courses Taken

- Network Science
- Applied Stochastic Processes
- Empirical Analysis
- Computational Tools and Techniques for Data Analysis
- Machine Learning
- Applied Statistics I & II
- Optimization Techniques
- Theoretical Statistics
- Information Theory
- Algorithm Design and Analysis
- Foundations of AI
- Advanced Programming Languages

Research Experience

Research Interests: My research interests are in unsupervised learning, statistical learning theory, topological data analysis, computational geometry, and building software for scientific computing and reproducible research.

Research Associate **Fall 2018-Present, 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 theoretical extensions to the *Mapper* framework, an often used modality for performing TDA. My work lead to the development of an algorithmic solution which greatly reduces the complexity of the *Mapper* framework and enables a more tractable analysis of *mapper* constructions in both the exploratory setting and in the context of Persistent Homology. A journal article demonstrating the utility of this solution is in development, available as a draft [1].

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

I was hired by Dr. Steven Arnold in the Multiscale Modeling Materials and Structures Division for a 10-week internship at NASA to use Machine Learning to explore the possibility automatically capturing process-property-structure (PSP) relationships through the use of a ML-based surrogate model trained on stress-response data simulated via the Generalized Method of Cells. An additional requirement of the project (per NASAs Vision 2040 guidelines) was to incorporate experimental design methodology for interpreting the results. The project involved:

- Learning basic micromechanics and lamination theory
- Architecting a feed-forward neural network (the surrogate model) to model laminate stress-response data
- Modifying an optimization procedure (approximate coordinate exchange) to minimize a different loss function (conditional mutual information) towards generating optimal designs

A technical report and subsequent journal is planned for the future. Presentation material, code, and a draft of the technical report is available upon request for U.S. citizens only.

Graduate Research Assistant **2015 - 2018**

Wright State University *Machine Learning and Complex Systems Lab*

I joined the Machine Learning and Complex Systems lab in 2015 initially as part of an independent study, which in turn lead to a graduate research assistantship. I was assigned to a research project aimed at modeling macroscopic aspects of real-world traffic networks via a dynamic network model (i.e. a modified stochastic block model). The topic areas I focused on for the project include:

- Density-based clustering techniques and theory
- Dynamic/Temporal Network Models
- Trajectory mining and modeling

Prior to using the stochastic block model, the project requiring first converting raw positioning/track information into a dynamic network representation. Much of my work involved researching scalable, theory-first approaches to identifying the 'nodes' in the network, which corresponded to clusters of movement. My approach involved augmenting the *cluster tree*, a level-set shape characteristic of an estimated density function, with semi-supervised information. 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]

Student 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 a new subcontractor, 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. The effort lead to multiple publications [5, 6]. I also worked on:

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

Undergraduate Research Assistant **2013 - 2014**

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

As an undergraduate student, I was hired at the Air Force Institute of Technology (AFIT) to do research in a heavily 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. This 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

Publications

Under Development.....

(In Development): **Matt Piekenbrock**, Derek Doran, and Ryan Kramer. Efficient multi-scale

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

simplicial complex generation for mapper. *SIAM Journal on Applied Algebra and Geometry*, 2018. Draft version available after: `http://mattpiekenbrock.com/resources/indexed_mapper.pdf`.

Matt Piekenbrock and Derek Doran. Intrinsic point of interest discovery from trajectory data. *arXiv preprint arXiv:1712.05247*, 2017.

Journals

(Under Review) Michael Hahsler, **Matt Piekenbrock**, and Derek Doran. dbscan: Fast density-based clustering with R. *Journal of Statistical Software*, 2016.

Conference Papers

Jace Robinson and Derek Doran. Seasonality in dynamic stochastic block models. In *Proceedings of the International Conference on Web Intelligence*, pages 976–979. ACM, 2017.

Matt Piekenbrock, Jace Robinson, Lee Burchett, Scott Nykl, Brian Woolley, and Andrew Terzuoli. Automated aerial refueling: Parallelized 3d iterative closest point: Subject area: Guidance and control. In *Aerospace and Electronics Conference (NAECON) and Ohio Innovation Summit (OIS), 2016 IEEE National*, pages 188–192. IEEE, 2016.

Jace Robinson, **Matt Piekenbrock** Lee Burchett, Scott Nykl, Brian Woolley, and Andrew Terzuoli. Parallelized iterative closest point for autonomous aerial refueling. In *International Symposium on Visual Computing*, pages 593–602. Springer International Publishing, 2016.

Matthew Maurice, **Matt Piekenbrock**, and Derek Doran. Waminet: An open source library for dynamic geospace analysis using wami. In *Multimedia (ISM), 2015 IEEE International Symposium on*, pages 445–448. IEEE, 2015.

Abstracts

Matt Piekenbrock and Derek Doran. Exploring information-optimal network discretization for dynamic network analysis. *Sunbelt Social Networks Conference of the International Network for Social Network Analysis*, page 262, 2016.

Open Source Contributions

dbscan (R package)[2] Coauthor
clustertree (R package)[3] Author
Mapper (R package)[4] Author

Awards, Extra Curricular, Misc.

Outstanding Masters Student Award (Computer Science): WSU 2017-2018 academic year
Student participant and presenter: NSF TRIPODS TGDA Summer School and Workshop
Regional Model United Nations Annual Conference: Served in Volunteer Staff (2016 - 2017)
Outstanding Position Paper Award: National Model United Nations Annual Conference (2014)
Outstanding Delegation Award: National Model United Nations Annual Conference (2013)

[2] `https://github.com/mhahsler/dbscan`
[3] `https://github.com/peekxc/clustertree`
[4] `https://github.com/peekxc/mapper`