

Matthew Piekenbrock

Curriculum Vitae

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

Research Experience

Research Interests: My research interests are in unsupervised learning, statistical learning theory, computational geometry, and building software for the purpose of 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 the context of Persistent Homology. A journal article demonstrating the utility of this solution is currently in development, but available as a draft, see [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 data generated from 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 mechanics 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) to generate 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

Wright State University

2015 - 2018

Web and Complex Systems Lab

While at the WaCS lab, the topic areas I've focused on include:

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

The research project I was assigned aimed to modeling real-world traffic networks at a macroscopic scale. The goal of the project is to turn raw positioning/track information into a dynamic network representation, and then model that representation. Much of my work in the project involved researching viable theory-first approaches to large-scale density-based clustering. Specifically, my work has focused on augmenting the cluster tree, a shape characteristic of an estimated density function, with semi-supervised information for purpose of point of interest (POI) discovery in geospatial contexts [2], to be used as the 'vertices' in the dynamic network representation. My research is supported by the Center for Surveillance Research, a National Science Foundation I/UCRC.

Student Participant

Google Summer of Code 2017

Summer 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 mixture of code development which culminated in the form of an R package, as well as deep research to further understand the theory and utility of the cluster tree. For more details, see the project page¹.

Student Research Associate

Air Force Institute of Technology

2014 - 2016

Oak Ridge Institute for Science and Education

I 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:

- Parallelizing existing atmospheric absorption routines with OpenCL through MATLABs MEX interface
- A model for predicting web navigation patterns using Hierarchical Markov Models
- A prototypical UI to to enhance searching and viewing of 3D models using ThreeJS

Undergraduate Research Assistant

Air Force Institute of Technology

2013 - 2014

Southwestern Ohio Council for Higher Education

As my first part-time position in academia, I worked on a diverse set of projects, often assisting graduate or doctoral students working in the research area with primarily programmatic or educational tasks. This involved:

- Codifying a novel nonlinear optimization algorithm in ANSI-C
- Implementing an unsplittable flow approximation algorithm in C++ and Python
- Creating a conversion tool that allowed for converting back and forth between Oracle's Abstract Data Type specification to its equivalent representation as an XMLType

Publications

Under Development.....

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

¹<https://summerofcode.withgoogle.com/archive/2017/projects/5919718795902976/>

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. Wamnet: 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>