Matt Piekenbrock

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— Education

Northeastern University — **Boston, MA**
PhD in Computer Science (advisor: Jose Perea) — 08/2024 (Expected)

Michigan State University (transferred) — **East Lansing, MI**
PhD in Computational Mathematics, Science, and Engineering — 09/2019 – 05/2021

Wright State University — **Dayton, OH**
M.S. in Computer Science (advisor: Derek Doran) — 05/2018
B.S. in Computer Science + Minor in Statistics — 12/2015

Awards & Fellowships

- Outstanding Masters Student Award (Computer Science) — WSU, 2017/2018
- Ginther Fellow — 08/2019 – 05/2021
- ORISE Fellow — 07/2014 – 03/2017
- SOCHE Fellow — 12/2013 – 06/2014

— Skills

Languages: Python · R · C++ · CUDA · OpenCL · OpenMP · MPI · Cython
Tools / Libs: Meson · CMake · Git · Bash · Slurm · NumPy · SciPy · PyTorch
Specialities: Machine Learning · Optimization · Linear algebra · Dim. Reduction · Topology · Comp. Geometry

— Experience

Perea Lab — **Northeastern University**
Graduate Research Assistant — 09/2019 – Present

- Developed algorithms[7,8] improving the efficiency of computing *Persistent Homology* in parameterized settings and demonstrated their utility in application domains, including manifold learning and time series analysis.
- Published open-source Python packages‡ documenting my doctoral research in topological dimensionality reduction [*tallem*] and matrix function estimation [*primate*]
- Contributed talks to conferences, including the AMS23 and AMS24 Spring Eastern Sectional Meeting on Applied and Computational Topology, GTDAML23, ComPer23, JMM24, and UF-TDA24.

Air Force Research Laboratory — **KBR Wyle / ORAU**
Machine Learning Scientist — 06/2017 – 08/2019

- Developed geometric/topological loss functions for vision- or spatial- related tasks, such as object tracking from noisy video data and road detection from partially labeled LiDAR data.
- Published an open source R package extending the *Mapper* framework [*Mapper*] for topological data analysis. Parts of the software have since been incorporated into an AI startup[1] company. (R / C++)

Machine Learning & Complex Systems Lab — **Wright State University**
Graduate Research Assistant — 01/2015 – 05/2018

- Researched the use of *generative geometric graph models*[4] in predicting macroscopic patterns of real-world traffic networks inferred from time-varying trajectory data (e.g. GPS) and point-of-interest data (e.g. OSM)
- Developed trajectory mining and temporal network model validated on traffic simulation software [*sumor*]
- Gave bi-annual research talks to industry partners, project sponsors, and fellow researchers on how to incorporate clustering into dynamic geospatial network models for aerial surveillance applications.

Oak Ridge Institute for Science and Education — **Air Force Institute of Technology**
Civilian Research Fellow — 07/2014 – 03/2017

- Developed GPU-parallelized point registration algorithm[1,2] for high-resolution LIDAR data that facilitated real-time tracking of aircraft in turbulent conditions for the purpose of autonomous aerial refueling (C++/CUDA)
- Parallelized atmospheric absorption routines for AFITs *LEEDR* software package (C++/OpenCL)
- Worked within an interdisciplinary team assisting AF students solve mathematical optimization problems.

[1] See https://minedxai.com/ for more details

Internships

National Aeronautics and Space Administration — **Glenn Research Center**

SCaN Intern — 06/2022 – 08/2022

- Established bound on shortest-path-affecting critical points encountered by a low-earth orbit satellite network over a single orbital period [NASA technical report pending; draft available to U.S. citizens].‡
- Validated the above bound empirically on an elliptical orbital simulation of STARLINK satellites (Python / C++)
- Presented research findings to program managers at the Space Communications and Navigation (SCaN) program on the benefits of geometrically-informed routing in delay- and disruption-tolerant networks.

National Aeronautics and Space Administration — **Glenn Research Center**

LERCIP Intern — 06/2018 – 09/2018

- Worked on accelerating NASA's materials discovery and design process by researching the degree to which neural networks can infer multiscale structural properties from material stress-response data.
- Developed information-theoretic loss for process-structure-property inference which was successfully validated against a ground-truth micromechanics models (GMC); see subsequent publications[5,6] for details.

Google Summer of Code — **R Project for Statistical Computing**

Student Participant — 05/2017 – 08/2017

- Wrote successful Google Summer of Code grant[2] ($\leq$12% acceptance rate) to research the theory of density-based clustering and its connections to cluster trees (mentored by Dr. Mikhail Belkin and Dr. Michael Hahsler)
- Published R packages on CRAN [*dbscan*, *clustertree*] and a journal at the Journal of Statistical Software.[3]

Teaching Experience

- ⊛ Teaching assistant - Unsupervised Learning — Spring '24, Fall '23, Fall '22 (NEU)
- ⊛ Teaching assistant - Data Mining Techniques — Summer '23 (NEU)
- ⊛ Teaching assistant - Supervised Machine Learning — Spring '23 (NEU)
- ⊛ Teaching assistant - Computational Modeling & Data Analysis — Fall '20 (MSU)

‡Publications & Open Source Contributions

The OS packages below have received over **3.2+ million** downloads / **120+** package dependents (as of 01/2024):

⊛ ***primate***	Python / C++	[gh]/peekxc/primate	*Author*
⊛ ***dbscan***	R / C++	[gh]/mhahsler/dbscan	*Coauthor*
⊛ ***Mapper***	R / C++	[gh]/peekxc/Mapper	*Author*
⊛ ***tallem***	Python / C++	[gh]/peekxc/tallem	*Coauthor*
⊛ ***clustertree***	R	[gh]/peekxc/clustertree	*Author*
⊛ ***sumor***	R / C++	[gh]/peekxc/sumor	*Author*

The research publications I (co-)authored below have collectively been cited over **800+ times** (as of 01/2024):

1. **M. Piekenbrock**, J. Robinson, L. Burchett, S. Nykl, B. Woolley, and A. Terzuoli, "Automated aerial refueling: Parallelized 3D iterative closest point: Subject area: Guidance and control," in 2016 IEEE National Aerospace and Electronics Conference (NAECON) and Ohio Innovation Summit (OIS), 2016, pp. 188–192. (DOI: 10.1109/NAECON.2016.7856797)
2. J. Robinson, **M. Piekenbrock**, L. Burchett, S. Nykl, B. Woolley, and A. Terzuoli, "Parallelized iterative closest point for autonomous aerial refueling," in Advances in Visual Computing: 12th International Symposium, ISVC 2016, Las Vegas, NV, USA, December 12-14, 2016, Proceedings, Part I 12, 2016, pp. 593–602. (DOI: 10.1007/978-3-319-50835-1_53)
3. M. Hahsler, **M. Piekenbrock**, and D. Doran. "dbscan: Fast density-based clustering with R." Journal of Statistical Software 91 (2019): p. 1-30. (DOI: 10.18637/jss.v091.i01)
4. **M. Piekenbrock** and D. Doran. "Intrinsic point of interest discovery from trajectory data." (DOI: 10.48550/arXiv.1712)
5. J.Stuckner, **M. Piekenbrock**, S.M. Arnold, and T.M. Ricks, "Optimal experimental design with fast neural network surrogate models," Computational Materials Science, vol. 200, p. 110747–110748, 2021.
6. S.M. Arnold, **M. Piekenbrock**, T.M. Ricks, and J. Stuckner, "Multiscale analysis of composites using surrogate modeling and information optimal designs," in AIAA Scitech 2020 Forum, 2020, p. 1863–1864. (DOI: 10.2514/6.2020-1863)
7. **M. Piekenbrock** and J. Perea, "Move schedules: fast persistence computations in coarse dynamic settings," Journal of Applied and Computational Topology, pp. 1–45, 2024. (DOI: 10.1007/s41468-023-00156-3)
8. **M. Piekenbrock** and J. Perea, "Spectral relaxations of the persistent rank invariant," in 2024 Joint Mathematics Meetings.

[2]GSOC project ID: 5919718795902976-2017