

Christopher J. Tralie

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Research Interests

Geometric signal processing, applied topology, nonlinear time series analysis, music information retrieval, video processing, computer graphics

Academic Positions

2017 - Present **Postdoctoral Associate**, *Duke University Department of Mathematics*.

Education

2011 - 2017 **Ph.D.**, *Duke University*, Durham, NC, *Electrical and Computer Engineering*.

Advisers: Guillermo Sapiro, John Harer

Dissertation Title: "Geometric Multimedia Time Series"

2011 - 2013 **M.S.**, *Duke University*, Durham, NC, *Electrical and Computer Engineering*.

2007 - 2011 **B.S.E.**, *Princeton University*, Princeton, NJ, *Electrical Engineering with Certificate in Computer Science* (Cum Laude).

Honors and Awards

2018 Deezer Hacking Audio And Music Research (HAMR) Best Code Award, Paris, France

2016 Top 5% Teachers At Duke: Dean's award for ranking among top 5% (university wide) in student evaluations for *Quality of Course or Intellectual Stimulation*, Duke University, Spring 2016

2015 Duke University Department of Electrical Engineering Best Poster Award

2015 Duke University Bass Family Teaching Fellowship

2011 National Science Foundation Graduate Fellowship

2011 G. David Forney Jr. Prize in Signals and Systems at Princeton University

2009 Summer Undergraduate Fellowship in Robotics at Duke University: *Awarded through the National Science Foundation's Research Experience for Undergraduates (REU) Program*

2007 Lockheed Martin National Merit Scholar

2006 Pennsylvania Governor School for the Sciences, *Carnegie Mellon University*

Grants

2017 Helped write the Air Force Office of Scientific Research (AFOSR) grant "Geometric And Topological Methods for Multi-Modal Data Analysis And Fusion," which was successfully funded (joint with Paul Bendich and John Harer)

2014 Wrote the technical overview for the NSF Big Data Grant "Topological Data Analysis and Machine-Learning with Community-Accepted Features" (Award No. 1447491), which was successfully funded (joint with Paul Bendich and John Harer)

Publications

Journal Publications

Paul Bendich, Ellen Gasparovic, John Harer, and Christopher J. Tralie. Scaffoldings and spines: Organizing high-dimensional data using cover trees, local principal component analysis, and persistent homology. *Research in Computational Topology*, 13, 2018.

Christopher J Tralie. Self-similarity based time warping. *arXiv preprint arXiv:1711.07513 (In Submission)*.

Christopher J. Tralie and Jose A. Perea. (quasi)periodicity quantification in video data, using topology. *SIAM Journal on Imaging Sciences*, 11(2):1049–1077, 2018.

Boyan Xu, Christopher J. Tralie, Alice Antia, Michael Lin, and Jose A. Perea. Twisty takens: A geometric characterization of good observations on dense trajectories. *arXiv preprint arXiv:1809.07131 (In Submission)*, 2018.

Published Refereed Conference Proceedings

Travis Deyle, Christopher J Tralie, Matthew S Reynolds, and Charles C Kemp. In-hand radio frequency identification (rfid) for robotic manipulation. In *IEEE International Conference on Robotics and Automation (ICRA), Karlsruhe, Germany*, pages 1234–1241. IEEE, 2013.

Christopher J Tralie. Early mfcc and hpcp fusion for robust cover song identification. In *18th International Society for Music Information Retrieval (ISMIR), Suzhou, China*, 2017.

Christopher J Tralie. Cover song synthesis by analogy. In *19th International Society for Music Information Retrieval (ISMIR), Paris, France*, 2018.

Christopher J Tralie and Paul Bendich. Cover song identification with timbral shape sequences. In *16th International Society for Music Information Retrieval (ISMIR), Malaga, Spain*, pages 38–44, 2015.

Christopher J Tralie, Paul Bendich, and John Harer. Multi-scale geometric summaries for similarity-based sensor fusion. In *The 40th IEEE Aerospace Conference (In Submission), Big Sky, Montana*, 2019.

Christopher J Tralie and Matthew Berger. Topological eulerian synthesis of slow motion periodic videos. In *IEEE International Conference on Image Processing, Athens, Greece*, 2018.

Christopher J Tralie, Abraham Smith, Nathan Borggren, Jay Hineman, Paul Bendich, Peter Zulch, and John Harer. Geometric cross-modal comparison of heterogeneous sensor data. In *Proceedings of The 39th IEEE Aerospace Conference, Big Sky, Montana*, 2018.

Peer Reviewed Short Papers / Abstracts

Paul Bendich, Ellen Gasparovic, John Harer, and Christopher Tralie. Geometric models for musical audio data. In *Proceedings of the 32st International Symposium on Computational Geometry (SOCG), Boston, MA*, 2016.

Jose Perea and Christopher Tralie. Sliding windows and persistence. *The Journal of The Acoustical Society of America (JASA), Boston, MA*, 2017.

Christopher Tralie and Amanda Lazarus. A head of our times: Reimagining the heads in the brummer collection via real-time face mapping. *The Age of Sensing 5th International Conference on Remote Sensing in Archeology, Durham, NC*, 2014.

Christopher Tralie, Nathaniel Saul, and Rann Bar-On. Ripser.py: A lean persistent homology library for python. *The Journal of Open Source Software (JOSS)*, 2018.

Christopher J Tralie. High dimensional geometry of sliding window embeddings of periodic videos. In *Proceedings of the 32st International Symposium on Computational Geometry (SOCG), Boston, MA*, 2016.

Christopher J. Tralie, Goodwin S. Matthew, and Guillermo Sapiro. Automated detection of stereotypical motor movements in children with autism spectrum disorder using geometric feature fusion. *International Society for Autism Research (INSAR), Rotterdam, The Netherlands*, 2018.

Whitepapers / Not Peer Reviewed

Christopher J Tralie. Cover songs via sequences of local mfcc self-similarity matrices. In *Music Information Retrieval Evaluation Exchange (MIREX)*, 2015.

Christopher J Tralie. Cover song identification using similarity fusion of hpcps, mfccs, and mfcc ssms. In *Music Information Retrieval Evaluation Exchange (MIREX)*, 2017.

Christopher J Tralie. Graphditty: A software suite for geometric music structure visualization. In *19th International Society for Music Information Retrieval (ISMIR), Late Breaking Session*, 2018.

Christopher J Tralie and John Harer. Moebius beats: The twisted spaces of sliding window audio novelty functions with rhythmic subdivisions. In *18th International Society for Music Information Retrieval (ISMIR), Late Breaking Session*, 2017.

In Preparation

John Harer, Francis Motta, and Christopher J Tralie. Polynomial time computable ordered merge tree metrics using hyperbolic structures.

Invited Talks

- 2019 "Twisty Takens: Constructing Any 2-Manifold from A Sliding Window Embedding," AMS Spring Southeastern Sectional Meeting, Auburn University
- 2019 "Topological Periodicity Analysis in Multimedia Time Series": Joint Math Meeting (JMM) Baltimore, MD
- 2018 "Geometric Audiovisual Signal Processing (GASP!): Video And Music Processing with A Twist": Telecom Paristech
- 2018 "Audio Cover Songs: Analysis And Synthesis": Duke University Data Dialogue Seminar
- 2017 "From Musical Rhythms To Vibrating Vocal Folds: Geometric (Quasi)Periodicity Quantification in Multimedia Time Series." NC State Department of Mathematics
- 2017 "Topological Rhythm Hierarchy Quantification in Musical Audio." SIAM Conference on Applied Algebraic Geometry, Georgia Tech.
- 2016 "Geometry Aided Music Structure Analysis And Cover Song Identification" (SAS)
- 2015 "Intro to the Duke Cluster and Data Hacks" (Duke University)
- 2014 "The Geometry and Topology of Musical Audio Data" (Duke University)

Undergraduate Research Supervised

- 2017-2018 Alice Antia (Math), Michael Lin (Math), Boyan Xu (Math). "Twisty takens: A geometric characterization of good observations on dense trajectories." Summer@ICERM research project (also journal paper in submission).
- 2017-2018 Dev Dabke (CS/Math), Erin Taylor (CS/Math). "Geometric Approaches for Basketball Player Trajectory Analysis." Duke Math senior honors thesis / academic writing mentorship.
- 2017 Biraj Pandey (Math), Tim Sudijno (Math). "Recurrence in Dynamic Networks." Summer@ICERM research project.
- 2015 Marshall Ratliff (Math). "Introducing the Cover tree to Music Information Retrieval." Duke Math senior honors thesis.

- 2014 Joy Patel (Math/CS). "Towards Automated Synapse Detection in Electron Microcopy Image." Semester long independent study
- 2014 Julia Ni (Math), Joy Patel (Math/CS), Courtney Bennett Smith (Math), Roger Zou (Math). "Mitochondria Detection in 3D Brain Images." Duke Data Plus summer project.
- 2014 Marshall Ratliff (Math), Derrick Nowak (Math). "Classifying Musical Genres: An Investigation into Sorting Music using Topology." Duke Data Plus summer project.

Teaching / Mentoring

- 2019 Upcoming Mentor in WiMIR: Women in Music Information Retrieval
- 2018 Co-Instructor At Summer School on Topological Data Analysis at Levico Terme, Italy. Labs found at <http://github.com/ctralie/TDALabs>
- 2018-Present STEAM-Center / CyberPatriot Mentor at Lakeland Elementary/Middle School in Baltimore, Maryland
- 2017 Summer@ ICERM Topological Data Analysis Co-Instructor / Teaching Assistant
- 2016 Summer School Teaching Assistant At Technical University of Munich, Germany on "Topological Time Series Analysis - Theory And Practice"
- 2016 Instructor of Record of a new course I designed, CS/MATH 290: "Digital 3D Geometry," at Duke University. A ground up approach to 3D geometry with a statistics and signal processing focus. Assignments in Javascript/WebGL on sound modeling in virtual acoustic environments and modeling rotations. Assignments in numpy on 3D shape statistics, 3D shape alignment, and spectral mesh processing. <http://www.ctralie.com/Teaching/COMPSCI290>
- 2016-2018 Guest Lecturer on Topological Data Analysis at Duke University (three lectures: two for Dr. John Harer and one for Dr. Francis Motta)
- 2015 3D geometry and computer graphics independent study mentor to two high school students from North Carolina School for Science and Math
- 2014 Guest lecture / lab design in "Data Expeditions" on "Topology + Music Audio Data" and "Musical Pitches And Chroma Features," sponsored by the Information Initiative at Duke
- 2014 Mentor in 9 Week "Data and Brains" Undergraduate NSF Summer Research Program at Duke University sponsored by the math department
- 2013 - 2017 Member of Duke University Certificate in College Teaching (CCT) Program
Participated in "College Teaching Practicum" spring 2013 and "Teaching Triangles" teaching evaluations spring 2016
- 2009 - 2011 Princeton University Engineering "Interactor"
Assisted a faculty member and advised eight freshman engineering students with their courses
- 2008 - 2011 Princeton University Peer Math Tutor
Tutored Undergraduate students one-on-one in Math 104: Calculus 2, Math 201: Multivariable Calculus, Math 203: Advanced Multivariable Calculus, and Math 202: Linear Algebra

- 2010 Princeton University Math Study Hall Facilitator
Selected to lead a pilot weekly study hall program sponsored by the math department

Conference / Journal Reviewing

- 2018 International Society for Music Information Retrieval (ISMIR)
2018 Journal of Information Fusion (INFUS)
2018 34th International Symposium on Computational Geometry (SOCG)
2016 EURASIP Journal on Audio, Speech, and Music Processing
2015 Iberoamerican Congress on Pattern Recognition (CIARP)

Other Scholarly Activity

- 2013 - Member of "Information Initiative at Duke" (IID)
Present
2015-2017 MIREX Music Benchmarking Competition Task Captain in "Cover Song Identification"
2015 US Air Force Research Labs (AFRL) Visiting Faculty Research Program

Industry Experience

- 2008 Lockheed Martin Summer Internship in Software Development
Wrote an R&D project management plugin for the Eclipse IDE (contributed over 17k Lines of Code)

Programming Languages and Lab Experience

- Programming Languages C, C++, Java, Python, Javascript, Matlab, Perl, HTML, OpenGL/WebGL, Linux Tools, Java Applet Development, ROS robot operating system
- Master's Project in Radar Signal Processing (2012)
Created a 2D positioner robot from scratch to move a K-band horn antenna in front of a 4'x4'x4' anechoic box, and used this apparatus to create SAR images
- Undergraduate EE Core Lab (2010)
"Carlab" ELE 302 Junior Electrical Engineering Design Project.
Replaced radio control systems on an RC-sized car with our own autonomous control circuits
Programmed a DSP56800 series microprocessor to implement PID cruise control, PWM steering control, and line following using a C2 camera and the NTSC video standard

Spoken Languages

- Native English
Proficient French