Curriculum Vitae   Michael J. Catanzaro

Geometric Data Analytics, Inc.
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Employment

- Senior Scientist, Geometric Data Analytics, Inc., June 2022 - present.

- Assistant Professor, Iowa State University, August 2018 - May 2022.

- Postdoctoral Research Associate, University of Florida, August 2016 - July 2018.
  Mentor: Peter Bubenik.

Education

- Ph.D. Mathematics, Wayne State University, March 2016.
  Advisors: Dr. John R. Klein, Department of Mathematics, and
  Dr. Vladimir Y. Chernyak, Department of Chemistry.

- M.A. Mathematics, Wayne State University, December 2011.
  Advisor: Dr. Robert R. Bruner, Department of Mathematics.

- B.S. Physics, Wayne State University, December 2010.

- B.S. Mathematics, Wayne State University, December 2010.

Research Interests

- Machine learning, Reinforcement learning, Risk and Safety of perception models, deep learning.

- Topological data analysis, multiparameter persistence, multiparameter persistence modules.

Publications

Accepted articles

4. Catanzaro, Michael J.; Dharna, Aaron; Hineman, Jay; Polly, James B.; McGoff, Kevin; Smith, Abraham D.; Bendich, Paul, *Topological Decompositions Enhance Efficiency of Reinforcement Learning*, Accepted to IEEE Aeroconference, 2024.

3. Jin, Yinzhu; McDaniel, Rory; Tatro, N. Joseph; Catanzaro, Michael J.; Smith, Abraham D.; Bendich, Paul; Dwyer, Matthew B.; Fletcher, P. Thomas, *Implications of Data Topology for Deep Generative Models*. Accepted to Frontiers in Computer Science.

2. Smith, Abraham D.; Catanzaro, Michael J.; Angeloro, Gabrielle; Patel, Nirav; Bendich, Paul, *Topological Parallax: A Geometric Specification for Deep Perception Models*, Accepted to Neurips 2023. https://arxiv.org/abs/2306.11835.

1. Bubenik, Peter; Catanzaro, Michael J. *Multiparameter persistent homology via generalized Morse theory*. Accepted to Fields Institute Communications. Available at arxiv.org/abs/2107.08856.

Peer-reviewed articles

17. Zhou, Youjia; Lazovskis, Janis; Catanzaro, Michael J.; Zabka, Matthew; Wang, Bei, *Combinatorial Exploration of Morse–Smale Functions on the Sphere via Interactive Visualization*, 2023 Topological Data Analysis and Visualization (TopoInVis). (2023), 51 − 60, DOI 10.1109/TopoInVis60193.2023.00012.

16. Catanzaro, Michael J.; Rizzo, Sam; Kopchick, John; Chodury, Asadur; Rosenberg, David R.; Bubenik, Peter; Diwadkar, Vaibhav A, *Topological Data Analysis Captures Task-Driven fMRI Profiles in Individual Participants: A Classification Pipeline Based on Persistence*, Neuroinformatics. (2023), DOI 10.1007/s12021-023-09645-3.

15. Catanzaro, Michael J.; Vose, Brantley, *Harmonic Representatives in homology over arbitrary fields*, J Appl. and Comput. Topology. **7** (2023), 643–670, DOI 10.1007/s41468-023-00117-w arxiv.org/abs/2110.10885.

14. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *Fluctuations of cycles in a finite CW complex*, Isr. J. Math. **248** (2022), 315–354, DOI 10.1007/s11856-022-2303-9. arxiv.org/abs/1710.07995.

13. Catanzaro, Michael J.; Przybylski, Lee; Weber, Eric S., *Persistence Landscapes of Affine Fractals*, Demonstratio Mathematica. **55** (2022), 163–192, DOI doi.org/10.1515/dema-2022-0015 arxiv.org/abs/2201.02552.

12. Catanzaro, Michael J.; Zabka, Matthew J., *A Model for Random Chain Complexes*, Abh. Math. Semin. Univ. Hambg. **91** (2021), 335–344, DOI 10.1007/s12188-021-00248-w arxiv.org/abs/1901.00964.

11. Salch, Andrew; Abdallah, Hassan; Regalski, Adam; Suryadevara, Raviteja; Catanzaro, Michael J.; Diwadkar, Vaibhav A. *From mathematics to medicine: A practical primer on topological data analysis (TDA) and the development of related analytic tools for the functional discovery of latent structure in fMRI data*, PLOS One. (2021), doi.org/10.1371/journal.pone.0255859

10. Catanzaro, Michael J.; Curry, Justin; Fasy, Brittany Terese; Lazovskis, Janis; Malen, Greg; Riess, Hans; Wang, Bei; Zabka, Matthew, *Moduli Spaces of Morse Functions for Persistence*, J. Appl. and Comput. Topology. **4** (2020), 353–385, DOI doi.org/10.1007/s41468-020-00055-x arxiv:1909.10623.

9. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *Exciton Scattering via Algebraic Topology*, J. Topology and Analysis. **11** (2019), 251–272. DOI doi:10.1142/S1793525319500110 arXiv:1505.02365.

8. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *A higher Boltzmann Distribution*, J. Appl. and Comput. Topology. **1** (2017), 215–240, DOI doi:10.1007/s41468-017-0006-9 arXiv:1506.06775.

7. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *Stochastic Dynamics of Extended Objects in Driven Systems: I. Higher-Dimensional Currents in the Continuous Setting*, Chem. Phys. **481** (2016), 5–18, DOI doi:10.1016/j.chemphys.2016.08.021 arxiv:1609.00336.

6. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *Stochastic Dynamics of Extended Objects in Driven Systems II: Current Quantization in the Low-Temperature Limit*, Chem. Phys. **481** (2016), 19–27, DOI doi:10.1016/j.chemphys.2016.08.020 arxiv:1609.00334.

5. Catanzaro, Michael J.; Shi, Tian; Tretiak, Sergei; Chernyak, Vladimir Y., *Counting the number of excited states in organic semiconductors systems using topology*, J. Chem. Phys. **142** (2015), 1–12, DOI doi:10.1063/1.4908560 arxiv:1612.03434.

4. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R., *Kirchhoff's theorems in higher dimensions and Reidemeister torsion*, Homology, Homotopy, and Applications. **17** (2015), 165–189, DOI doi:10.4310/HHA.2015.v17.n1.a8 arxiv:1206.6783.

3. Li, Hao; Catanzaro, Michael J.; Tretiak, Sergei; Chernyak, Vladimir, *Excited-state structure modifications due to molecular substituents and exciton scattering in conjugated molecules*, J. Phys. Chem. Let. **5** (2014), 641–647, DOI doi:10.1021/jz4027198 arxiv:1612.03523.

2. Catanzaro, Michael J.; Chernyak, Vladimir Y.; and Klein, John R., *On Kirchhoff's theorems with coefficients in a line bundle*, Homology, Homotopy, and Applications. **15** (2013), 267–280, DOI doi:10.4310/HHA.2013.v15.n2.a16 arxiv:1207.2822.

1. Catanzaro, Michael J., *Generalized Tonnetze*, J. Math. Music. **5** (2011), 117–139, DOI doi:10.1080/17459737.2011.614448 arxiv:1612.03519.

Preprints

2. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R. *Probability measures on graph trajectories*. Available on the arXiv at arXiv:2104.13566.

1. Catanzaro, Michael J.; Chernyak, Vladimir Y.; Klein, John R. *Hypercurrents*. Available on the arXiv at arxiv.org/abs/2010.06783.

Books, In progress

1. Bruner, Robert R.; Catanzaro, Michael J.; May, J. Peter. *Characteristic Classes*. pp 97. Draft available at math.uchicago.edu/~may/CHAR/charclasses.pdf.

Other publications

3. Catanzaro, Michael J. *A Topological Study of Stochastic Dynamics on CW Complexes*. Wayne State University Dissertations **1433** (2016). Available at digitalcommons.wayne.edu/oa_dissertations/1433/.

2. Catanzaro, Michael J. *Finitely Presented Modules over the Steenrod Algebra in Sage*. Master's thesis, Wayne State University, December 2011. Available at people.clas.ufl.edu/catanzaro/files/Essayfinal.pdf

1. Catanzaro, Michael J. *A user's guide: Dynamics and fluctuations of cellular cycles on CW complexes*, available at mathusersguides.com/enchiridion-vol-2-2016-mike-catanzaro/

Funding

Conference Organization

- Local organizer for the Underrepresented Students in Algebra and Topology Research Symposium (USTARS) at Iowa State University, April 2019.

Mentoring activities

Masters students

- Gabrielle Angeloro, 2020, Iowa State University. Wrote python package pyscapes implementing persistence landscapes in python (now at Geometric Data Analytics, Inc.).

Undergraduate students

- Brantley Vose, 2019 - 2021, Iowa State University: Harmonic chain representatives of persistent homology classes, including coding and developing a visualization package (now at Ohio State University).

- Samuel Swanson, 2017, University of Florida: Computing Hodge decompositions for persistent homology classes.

- Samuel Rizzo, 2017 - 2018, University of Florida: Applying persistence landscapes to study task modulation with fMRI data (now at Vanderbuilt University).

- Raviteja Suryadevara, 2015 - 2016, Wayne State University: Application of persistent homology to an fMRI study (now at Wayne State Medical School).

Refereeing

- Referee for Geometry and Topology; Homotopy, Homology, and its Applications; and Journal of Symposium on Computational Geometry.

- Reviewer for mathscinet.

Software developed

- *pyscapes*. A python implementation of persistence landscapes. Joint work with Gabby Angeloro. Now part of the persim module of the scikit-tda package. Original code available at github.com/gabbyangeloro/Masters_Thesis.

- *fpmods*. Finitely Presented Modules over the Steenrod Algebra. Joint work with Robert R Bruner, Sverre Lunøe-Nielsen, and Koen van Woerden. Currently under code-review at sagemath. Available at github.com/rrbruner/FPMods.

Technical skills

- Proficient in Python, C++, R, and Bash scripting.

- Written code for sage, Pythia, Hijing, and Root.

Presentations

Invited Presentations

30. *Topological Parallax: A Geometric Specification for Deep Perception Models*, UFTDA 2024. Gainesville, Florida, February 2024.

29. *Topological Parallax: A Geometric Specification for Deep Perception Models*, CodEx Seminar. Virtual. November 2023.

28. *Using persistence to study task modulation in fMRI*, Colorado State University Topology Seminar. Fort Collins, Colorado, November 2022.

27. *A workshop on Topological Data Analysis*, Midwest Big Data Summer School. Ames, Iowa, May 2021.

26. *Geometric perspectives on multiparameter persistence*, 6th CIMAT TDA workshop and winter school. Guanajuato, Mexico, January 2020.

25. *Multiparameter Persistence via Geometric Topology*, SIAM Conference on Applied Algebraic Geometry. Bern, Switzerland, July 2019.

24. *Stochastic Dynamics of Cellular Cycles*, Probability, Analysis, and Data Science Seminar. Iowa State University, October 2019.

23. *Topological Data Analysis*, Midwest Big Data Summer School. Ames, Iowa, May 2019.

22. *Geometric multiparameter persistence*, Computational and Applied Math Seminar, Iowa State University, April 2019.

21. *An Introduction to Topological Data Analysis*, Mathematical Association of America, Northwest Sectional Meeting. Southwest Minnesota State University, October 2018.

20. *Combining sub-level and let set persistence*, Multiparameter Persistent Homology, CMO, Oaxaca, Mexico, August 2018.

19. *Multiparameter persistence via geometric topology*, Algebraic Topology: Methods, Computation and Science 8, IST Austria, June 2018.

18. *Multiparameter persistence via geometric topology*, Bridging Statistics and Sheaves, Institute for Mathematics and its Applications, May 2018.

17. *Geometric multiparameter persistence*, Topology and Dynamics Seminar, University of Florida, December 2017.

16. *Stochastic Dynamics on CW complexes*, Applied Math and Analysis Seminar, Duke University, November 2017.

15. *Stochastic Dynamics of Cellular Cycles*, Geometry, Topology, and Data Seminar, The Ohio State University, September 2017.

14. *Stochastic Dynamics on CW Complexes*, Applied Topology in Bedlewo 2017, Bedlewo, Poland, June 2017.

13. *Exciton Scattering for Topologists*, Topology and Dynamics Seminar, University of Florida, March 2017.

12. *Stochastic Dynamics on CW Complexes*, two presentations given in Topology and Dynamics Seminar, University of Florida, October 2016.

11. *The Topology of Higher-Dimensional Currents and Langevin Processes*, Non-Equilibrium Statistical Physics, Telluride, CO, July 2016.

10. *Kirchhoff's laws in higher dimensions and Reidemeister torsion*, Topology Seminar, Brandeis University, November 2015.

9. *On the Boltzmann distribution and Hodge theory*, Young Topologists' Meeting, EPFL, July 2015.

8. *A generalization of the Boltzmann distribution & Hodge theory*, Graduate Student Topology and Geometry Conference, University of Illinois, March 2015.

7. *Counting Electronic Excitations In Organic Systems Using Algebraic Topology*, Topology Seminar, Johns Hopkins University, April 2014.

6. *Constructions in ∞-categories*, Talbot Workshop, 2014.

5. *Counting Electronic Excitations In Organic Systems Using Algebraic Topology*, Topology Seminar, Wayne State University, February 2014.

4. *Counting The Number Of Electronic Excitations In Branched Conjugated Molecules Using Algebraic Topology*, Physical Chemistry Seminar, Wayne State University, November 2013.

3. *Kirchhoff's theorems in higher dimensions and Reidemeister Torsion*, Topology Seminar, Wayne State University, October 2013.

2. *Counting Electronic Excitations using Cohomology*, Graduate Student Geometry and Topology seminar, University of Illinois Urbana-Champaign, May 2013.

1. *The Topology of Spaces of Triads*, The Undergraduate Mathematics Seminar, University of Michigan Dearborn, March 2010.

Contributed Presentations

9. *Morse theory and persistence*. Algebra and Geometry seminar, Iowa State University, September 2019.

8. *An Introduction to Topological Data Analysis*. Theoretical and Applied Data Science Seminar, Iowa State University, January 2019.

7. *Stochastic Dynamics on CW Complexes*, Applied Topology in Bedlewo 2017, Bedlewo, Poland, June 2017.

6. *On the Boltzmann distribution and Hodge theory*, Young Topologists' Meeting, EPFL, July 2015.

5. *A generalization of the Boltzmann distribution & Hodge theory*, Graduate Student Topology and Geometry Conference, University of Illinois, March 2015.

4. *Constructions in ∞-categories*, Talbot Workshop, 2014.

3. *Jet and Minijet Contributions to Transverse Momentum Correlations in High Energy Collisions*, The Undergraduate Physics Research Conference, Wayne State University, November 2009.

2. *The Topology of Spaces of Triads and Generalized Tonnetze*, The Undergraduate Research Conference, Wayne State University, November 2009.

1. *The Topology of Spaces of Triads*, The Young Mathematicians Conference, The Ohio State University, August 2009.

Teaching Experience

As the primary instructor, I developed syllabi, quizzes, and tests for the following courses.

- Algebraic Toplogy (ISU 506x): Spring 2021.

- Advanced Abstract Algebra II (ISU 505): Spring 2020.

- Advanced Abstract Algebra (ISU 504): Fall 2019.

- Directed study on Algebraic Topology (UF 5000): Fall 2019.

- Topology (ISU 502): Spring 2019.

- Advanced Topics in Topology: Differential Topology, Vector Bundles, and Characteristic Classes (UF 7396): Fall 2017.

- Advanced Calculus for Engineers and Physical Scientists I (UF 4102/5104): Winter 2017.

- Elementary Statistics (WSU 1020): Summer 2014.

- Algebra with Trigonometry (WSU 1050): Summer 2011, Fall 2011, Fall 2014, and Winter 2015.

- Mathematics in Today's World (WSU 1000): Summer 2013.

- Linear Algebra (ISU 207, WSU 2250): Spring 2021, Summer 2015.

- Pre-Calculus (WSU 1800): Winter 2011.

As the primary lecturer, I taught the following courses.

- Calculus 1 (ISU 165): Fall 2019, Fall 2020.

- Calculus 2 (ISU 166): Fall 2021.

- Calculus 3 (ISU 265, WSU 2313): Fall 2016 and Fall 2018.

Awards

- *Anderson Scholar Faculty Honoree*, University of Florida, College of Liberal Arts and Sciences, December 2017.

- *Bertram Eisenstadt Award for Outstanding Achievement in PhD Program*, Wayne State University, Department of Mathematics, May 2016.

- *Robert Irvan Endowed Mathematics Scholarship*, Wayne State University, Department of Mathematics, May 2015.

- *M.F. Janowitz Endowed Mathematics Scholarship*, Wayne State University, May 2014.

- *Maurice Zelonka Endowed Scholarship*, Wayne State University, Department of Mathematics, May 2013.

- *Outstanding Teaching Service*, Wayne State University, Department of Mathematics, May 2012.

- *Outstanding Undergraduate Award*, Wayne State University, Department of Mathematics, May 2010.

- *M.F. Janowitz Endowed Mathematics Scholarship*, Wayne State University, May 2010.

- *George B. Beard Student Prize for Excellent Presentation of Research*, Wayne State University, Department of Physics, November 2009.

- *Robert Irvan Endowed Mathematics Scholarship*, Wayne State University, Department of Mathematics, May 2009.

- *Vaden W. Miles Outstanding Undergraduate Award*, Wayne State University, Department of Physics, March 2009.

- *Undergraduate Scholarship*, Wayne State University, Department of Mathematics, May 2008.

- *Presidential Scholarship*, Wayne State University, June 2005.