Michael Robinson

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Education:

- Doctor of Philosophy in Applied Mathematics, 2008 Cornell University, Ithaca, NY. Dissertation: *Eternal solutions and heteroclinic orbits of a semilinear parabolic equation*
- Master of Science in Mathematics, 2003 Rensselaer Polytechnic Institute, Troy NY, Funded as an NSF VIGRE Fellow
- Bachelor of Science, *Summa cum Laude*, in Electrical Engineering, 2002 Rensselaer Polytechnic Institute, Troy NY

Overview:

I am developing theoretical and practical tools for advanced signal processing techniques. I am especially interested in the emerging field of topological methods for signal processing and systems analysis.

Current activities:

- Assistant professor of mathematics at American University, Washington, DC (July 2012-present). Working on several projects:
  - On the local organizing committee for SampTA 2015, to be held at American University
  - On the tenure-line hiring committee for the Mathematics and Statistics department for 2014.
  - Developing classroom demonstrations to teach partial differential equations through physics, music, and measurement
  - (Funded by AU Summer Scholars and Artists) Developing technqiues for indoor sonar analysis
  - (Funded by OSD/DDR&E/ATL) Developing algebraic topological methods for target tracking and inference
  - (Funded by AFOSR) Developing sheaf theoretic methods for network and information theoretic inference
  - (Funded by American University Faculty Research Support Grant 2013-2014, one Mathias Undergraduate Summer Award, and the DC Space Grant Consortium) Developing algorithms for extracting ocean wind speed and direction from satellite radar imagery
  - Studying bifurcations in quasilinear parabolic differential equations on unbounded domains
- Research Engineer at SRC, Inc. (formerly Syracuse Research Corporation), Syracuse, NY (June 2003-present, usually part-time). Working on a variety of engineering projects, including
  - Synthetic aperture radar (SAR) imaging

    - SAR image exploitation, involving coherent change detection, maritime domain awareness, and other intelligence-rich scenes
    - Simulationg Atmospheric and weather effects on SAR image quality
    - Simulating high-fidelity, high-resolution, coherent SAR image sets
  - Topological approaches to antenna measurement
  - Business development and proposal writing efforts for numerous defense and intelligence projects

Publications:

1. "Imaging geometric graphs using internal measurements," *J. Differential Equations* 260 (2016) 872-896. `http://dx.doi.org/10.1016/j.jde.2015.09.014`.
2. "Universal factorizations of quasiperiodic functions" *Sampling Theory and Applications* 2015 `arXiv:1501.06190`.
3. (with Cliff Joslyn and Emilie Hogan), "Towards a topological framework for integrating semantic information sources," *Semantic Technology for Intelligence Defense and Security* 2014.
4. *Topological Signal Processing*, Springer, January 2014.
5. "Knowledge-based antenna pattern extrapolation," *IEEE Trans. Ant. Prop.* Volume 62, Issue 1, January 2014, pp. 72-79.
6. "Understanding networks and their behaviors using sheaf theory," *IEEE Global Conference on Signal and Information Processing (GlobalSIP)* 2013 proceedings, Austin, Texas. Also available through arXiv.org:1308.4621
7. "The Nyquist theorem for cellular sheaves," *Sampling Theory and Applications (SampTA 2013)* proceedings, Bremen, Germany. Also available through arXiv.org:1307.7212.
8. "Multipath-dominant, pulsed doppler analysis of rotating blades," *IET Radar Sonar and Navigation*, Volume 7, Issue 3, March 2013, pp. 217-224.
9. "Asynchronous logic circuits and sheaf obstructions," *Electronic Notes in Theoretical Computer Science* (2012), pp. 159-177.
10. (with Robert Ghrist and Justin Curry) "Euler calculus and its applications to signals and sensing," in *Proceedings of Symposia in Applied Mathematics: Advances in Applied and Computational Topology*, Afra Zomorodian (ed.), 2012.
11. (with Robert Ghrist) "Topological localization via signals of opportunity," *IEEE. Trans. Sig. Proc.*, Vol. 60, No. 5, May 2012.
12. (with Robert Ghrist) "Euler-Bessel and Euler-Fourier transforms," *Inverse Problems*, Vol. 27, No. 12, 2011.
13. "Classification of connecting solutions of semilinear parabolic equations," *Electron. J. Diff. Eqns.*, Vol. 2011(2011), No. 61, pp. 1-10.

14. "A cell complex structure for the space of heteroclines for a semilinear parabolic equation," *Electron. J. Diff. Eqns.*, Vol. 2009(2009), No. 16, pp. 1-17.

15. "An asymptotic-numerical approach for examining global solutions to an ordinary differential equation," *Ergodic Theory and Dynamical Systems*, Vol. 29, (2009), pp. 223-253.

16. " Construction of eternal solutions for a semilinear parabolic equation," *Electron. J. Diff. Eqns.*, Vol. 2008(2008), No. 139, pp. 1-8.

17. "IMEX method convergence for a semilinear parabolic equation," *J. Differential Equations*, vol. 241, no. 2, October 2007, pp 225-236; doi:10.1016/j.jde.2007.07.001.

18. "A wavefront launching model for predicting channel impulse response," *ACES Journal*, vol. 22, no. 2, July 2007, pp 302-305.

19. "Polarizing frequency of a fluid plasma antenna element," *IEEE Antennas and Propagation Society Symposium*, 2004.

Patents:

- (with Andy Davis, Harvey Schuman, Don McPherson, John Wiley, David Hagenmayer) "Bench-Top Measurement Method, Apparatus and System for Phased Array Radar Apparatus Calibration," accepted for filing by the USPTO on February 11, 2011 under Application No. 13/025652.

- "System and Method for Antenna Pattern Estimation," accepted for filing by the USPTO on February 19, 2013 under Application No. 13/770291.

Preprints and Technical Reports:

- (with Matthew Hubler and Mark Verdi) "Experimental validation of the azimuthal high frequency cutoff of high resolution satellite radar images of the ocean," which shows that (1) a theoretical model of the azimuthal high frequency cutoff in maritime radar images is correct, but (2) that this is not the dominant factor in determining azimuthal blurring – the resolution can be considerably better.

- "A sheaf-theoretic perspective on sampling," `arXiv:1405.0324`, which develops a general sampling theory for sheaves using the language of exact sequences, and shows that the topology of the domain has a varying level of importance depending on the class of functions.

- (with Morgan DeHart, Matthew Hubler, Mark Verdi, and Zhu Zhu) "Measuring Ocean Winds from Space Using a Radar Satellite," AU-CAS-MathStats Technical Report 2014-1. `http://aladinrc.wrlc.org/handle/1961/16345`

- "Sheaf invariants for information systems," AU-CAS-MathStats Technical Report 2014-2. `http://aladinrc.wrlc.org/handle/1961/16346`

- "Analyzing wireless communication network vulnerability with homological invariants," `arXiv:1311.1532`, which introduces several cell complex models of wireless networks, a sheaf theoretic model their activity patterns, and a preliminary analysis of their vulnerability to jamming.

- (with Steven Casey, Jens Christensen, Isaac Pesenson, and Jose-Luis Romero), "Open problems in the applications of geometry and topology to sampling theory."

- "Inverse problems in geometric graphs using internal measurements," `arXiv:1008.2933`, which discusses algorithms and underlying theory for solving imaging problems in multipath-dominant, opportunistically illuminated environments, submitted.
- (with Robert Ghrist and Hank Owen) "DTIME: Discrete Topological Imaging for Multipath Environments," University of Pennsylvania ESE Technical Report, `http://repository.upenn.edu/ese_reports/6`.
- "Instability of a parabolic equation with a quadratic nonlinearity," `arXiv:0704.3989`, which gives an explicit construction showing that a certain critical point whose linearization is stable is in fact unstable. This is not a new result, but the proof is a good example of the blow-up method of H. Fujita.

Current research group:

- Zhu Zhu (graduate, joined Spring 2013): signal processing for oceanography
- Brian DiZio (undergraduate, joined Fall 2013): indoor sonar
- David D'Auria (undergraduate, Summer 2014): performance characterization of topological image processing
- Tara Shreve (undergraduate, joined Summer 2014): signal processing for oceanography
- Dhanesh Krishnarao (undergraduate, joined Fall 2014): wireless network vulnerability assessment

Past activities:

- Assistant professor of mathematics at American University
  - Co-organized the SampTA 2013 invited session on Sampling and Geometry.
  - (Funded by an Center for Teaching Research and Learning Teaching Enhancement Grant, Fall 2012) Developing classroom demonstrations to highlight applications of calculus.
- Research Engineer at SRC, Inc. (formerly Syracuse Research Corporation), Syracuse, NY
  - Over-land and urban radio propagation modeling (2003-2005)
  - Frequency allocation, radio network planning and validation (2003-2005)
  - GPS and low-profile antenna design (2004)
  - Phased array antenna element measurement and calibration (2005)
  - Synthetic aperture radar (SAR) imaging (2006-2009)
    - SAR image formation
    - SAR spread-spectrum tag simulation, geolocation, and decoding
- Postdoctoral researcher at University of Pennsylvania, PA (July 2008-June 2012).
  - Executing projects in three focus areas
    1. Topological extension to remote sensing, imaging, localization, and mapping
    2. Sheaf-theoretic methods to provide invariants for asynchronous logic circuits
    3. Integral transforms for the Euler calculus

  - Authored an independent proposal (currently under review by AFOSR) for asynchronous logic analysis and sheaf theory
  - Assisted in the authoring of several successful proposal efforts:
    * ONR: Algebraic topological structures for hidden modes
    * DARPA: Discrete topological imaging in multibounce environments
    * DARPA: Sensor Topology and Minimal Planning, Phase III
    * AFOSR MURI: Information dynamics as a foundation for network management

- Cornell University Center for Applied Mathematics, Ithaca, NY (Fall 2006-May 2008). Worked as Red Hat Enterprise Linux system administrator, managed private network of 25 computers for department users.

- Mindstream Computing, Nashua, NH (May 2001-August 2001). Developed rigorous tests and testing methods for their PCI-RapidIO bridge chip. Also wrote a CompactPCI Hot Swap controller for it. Tests checked PCI and RapidIO protocol and data integrity under a many system settings and stress levels. Tests and design were written in Verilog and C++.

- Flow Parametrics, LLC (Fall 2000 - 2003). Worked on utilities to link a CAD system (CADKEY) to finite-element meshing tools. Work involved providing a CADKEY user interface to existing NASA-developed surface mesher and a United Technologies Research Center-developed volume mesher. Work was done in C, C++, and Fortran.

- Pratt and Whitney, East Hartford, CT (summer internship 2000). Wrote state-of-the-art CAD utilities for use in the Computational Fluid Dynamics Department. The utilities were used for the design and analysis of jet engines. The utilities automatically corrected defects in CAD geometry, and facilitated the generation of solid bodies from wireframe meshes. Utilities were written in C and C++.

- CNC Software, Tolland, CT (summer internship 1999). Worked on an independent project to create a translation program, which allowed the Mastercam product to read STEP files. Worked with CNC director of software to define interface and processing requirements. Program was written in C and C++ and was implemented as a plug-in module for Mastercam.

- Pratt and Whitney, East Hartford, CT (summer internship 1998). Evaluated several STEP conversion programs being considered for use in transferring CAD data between aircraft manufacturers. Ran through numerous test cases, documented deficiencies and worked with CAD support programmers to correct geometric problems. The STEP standard allows platform-neutral exchanges of product data between CAD systems.

- Pratt and Whitney, East Hartford, CT (summer internship 1997). Created a knowledge base for the Pratt and Whitney help desk, centralizing information concerning the repair of computer equipment. This information was applied to CasePoint, a software package that the help desk agents would use to diagnose problems.

- CNC Software, Tolland CT (via 8th grade school enrichment program, 1994). Wrote a utility to delete objects within a polygonal region for their CAD/CAM product, Mastercam. Utility was written in C.

Selected Talks:

- Invited talk “Quasiperiodicity: processing signals using topology.” Applied Topology Seminar, University of Pennsylvania. Philadelphia, PA, April 27, 2015.
- Invited talk “Sheaf-based modeling of wireless communications.” Applied Algebraic Topology Network Seminar, April 1, 2015. Online talk through WebEx.
- Invited talk “Topological analysis of wireless networks.” NC State University ECE Seminar. Raleigh, NC. January 23, 2015.
- Contributed, refereed poster “A Sheaf-Theoretical Approach to Integrating Semantic Information Sensors.” Science of Multi-INT 2014, Chantilly, VA. September 9, 2014. (Classified meeting.)
- Invited talk “Morphisms of logic circuits.” Algebraic Topological Methods in Computer Science (ATMCS 6), Vancouver, BC, Canada, May 30, 2014.
- Invited talk “Computing using sheaves.” Pacific Northwest National Laboratory, Discrete Mathematics Seminar, May 21, 2014.
- Invited talk “A Unified Framework for Multi-INT Signal Processing.” Pacific Northwest National Laboratory, Signature Detection Initiative Seminar, May 20, 2014.
- Invited talk “Topological filters: theory and practice.” IMA Workshop on Communication, Sensing, and Actuation, Minneapolis, MN. March 4, 2014.
- Contributed talk “Topological data fusion.” Science of Multi-INT 2013, Chantilly, VA. September 24, 2013.
- Plenary talk “Sheaf morphisms describe digital signal processors.” Applied Topology 2013, Bedlewo, Poland, July 26, 2013.
- Invited talk “The Nyquist theorem for cellular sheaves.” Sampling Theory and Applications 2013, Bremen, Germany. July 3, 2013.
- Invited talk “How would you explain the Whitney embedding theorem to an engineer?” AMS Sectional Meeting, Akron, OH. October 21, 2012.
- Contributed talk “Sheaf theoretic methodology for multi-int target track inference.” Science of Multi-Int 2012, Chantilly, VA. September 26, 2012.
- Invited talk “Tools for antenna pattern extrapolation.” BackTrack working group. September 11, 2012.
- Invited talk “The Whitney embedding theorem in signal processing.” MAA MathFest, Madison, WI. August 4, 2012.
- Invited talk “Internal imaging of graphs and applications to urban sensing.” AFRL Math Seminar, Dayton, OH. May 30, 2012.
- “Tilting at windmills; forays into topological signal processing.” American University. April 24, 2012.
- “The Whitney embedding theorem for engineers.” Olin College. January 27, 2012.

- "Sheaf invariants for temporal logic." AMS/MAA Joint Meetings, Boston, MA. January 5, 2012.
- Invited talk "Euler integral transforms and applications." Workshop on Computational Topology. Fields Institute. November 8, 2011.
- Invited talk "Topology and geometry of graphs by distributed sensing." Applied Topology Workshop, Hakata, Japan September 2, 2011.
- Invited talk "Sounding your surroundings." IMA Summer School on Topological Analysis, University of Pennsylvania, week of 25 July 2011.
- (poster) "Sheaf theoretic invariants for computational networks." NMMC 2011, May 16, 2011. Also at NOLTA 2011, Kobe, Japan, September 5, 2011.
- Invited talk "Measuring topology and geometry by distributed sensing." NRO Technical Seminar (July 11, 2011). Also at Drexel University (April 14, 2011), Complex Networks MURI meeting (May 15, 2011). Demonstrated acoustic sounding equipment to supply opportunistic localization data.
- Invited talk "Logic circuits as sheaves." NSA Mathematics Colloquium. March 4, 2011. Also at Tulane University, March 25, 2011.
- (poster) "Euler characteristic integrals in signal processing." FFT 2011. February 17, 2011.
- Invited talk "Measuring the geometry of metric graphs by distributed sensing." Lehigh University. October 13, 2010. Also at Tulane University, October 28, 2010.
- "Forays into signal processing using the Euler characteristic integral." Princeton University, February 12, 2010.
- "Constructible sheaves and their cohomology for asynchronous logic and computation." GETCO 2010, Aalborg, Denmark. January 14, 2010. Also at SToMP group meeting, February 18, 2010.
- "Localization of Mobile Receivers using Opportunistic Signals." PASSHEMA Conference, Mansfield University. March 21, 2009.
- "Frequency assignment in land mobile radio systems." Applied Mathematics and Computational Science Seminar, University of Pennsylvania. October 10, 2008.
- "Some finite dimensionality results for the space of heteroclinic orbits of a semilinear parabolic equation." Dynamics Seminar, Cornell University. February 1, 2008.
- "Dynamics of a semilinear parabolic equation." Joint Mathematics Meetings, San Diego, California. January 6, 2008.
- "Instability of an equilibrium of a nonlinear parabolic equation with a negative definite linearization." Applied Mathematics Seminar, Université de Provence. March 13, 2007.
- "Towards a characterization of the dynamics of a semilinear parabolic differential equation." Mathematical Sciences Seminar, Cornell University. November 8, 2006.

- "Tug-of-war: how nonlinearity and the Laplacian interact." Olivetti Club, Cornell University. April 25, 2006.
- "Do electrons really spin?" Mathematical Sciences Seminar, Cornell University. February 8, 2006.
- "Studying the bifurcation behavior of a nonlinear PDE." Mathematical Sciences Seminar, Cornell University. October 5, 2005.
- "Polarizing frequency of a fluid plasma antenna element." Mathematical Sciences Seminar, Cornell University. November 8, 2004.

Teaching:

- Student projects supervised:
    1. (Independent study) Aurora Arop (undergraduate, Spring 2014): effects of economic inequality on elementary education
    2. (Master's project and independent research) Morgan DeHart (graduate, Fall 2012-May 2014): applied sheaves for computational networks; oceanographic buoy capabilities
    3. (Master's thesis) Matt Hubler (graduate, Spring 2013-May 2014): satellite imaging capabilities
    4. (Honors capstone) Mark Verdi (undergraduate, Summer 2013-May 2014): signal processing for oceanography
    5. (Summer research project) Tim Watkins (undergraduate, Summer 2013): dynamics of semilinear partial differential equations
    6. (Honors capstone) Julie Warner (undergraduate, graduated May 2013): sonar simulation and measurement
    7. (Independent research project) TJ Bollerman (undergraduate, graduated May 2013): sonar hardware
    8. (Independent study) Sam Krupa (undergraduate, Spring 2010-Spring 2012): discretization errors in Euler characteristic integration.
- MATH 601 "Harmonic Analysis," American University, Spring 2014. This course discusses the various transforms associated to self-adjoint operators, and along the way introduces distribution theory, Green's functions, and the spectral decomposition of the delta distribution.
- MATH 155 "Elementary Mathematical Models," American University, Spring 2014. This course introduces the concept of difference equations and functional equations for sequences, and applies them to a number of real world modeling examples.
- MATH 540 "Topology," American Universtiy, Fall 2013. This course introduces the concepts of point set topology: pseudometric spaces, topology, continuity, connectedness, and compactness.
- MATH 551 "Partial Differential Equations," American Unversity, Spring 2013. This course develops the solutions to the four most important partial differential equations: the transport equation, the heat equation, Laplace's equation, and the wave equation.
- MATH 560 "Numerical Analysis," American University, Fall 2012. Teaching analysis methods and programming techniques for solving mathematicsal problems using computers. This course is similar in spirit to MATH 320 at the University of Pennsylvania.

- MATH 221 “Calculus I,” American University, Fall 2012. This course examines the unique role of the concepts of *derivative* and *integral* in the quantification of change. In so doing, students will be able to explain how **any** quantitative method involving the measurement of change inevitably leads to these concepts. I emphasize connections of this material to applications, especially through the use of live classroom demonstrations.

- MATH 320 “Computer Methods,” University of Pennsylvania, Fall 2010. Worked as the sole instructor. The course taught solution of nonlinear equations, interpolation, and approximate methods for solving differential equations. This course was taught using a combined lecture/project format that required students to gain substantial with familiarity programming and with the course material by using data sets that I collected for them. Some students successfully learned to program during this course, having never tried it before. *See my website, under the Teaching tab for more detail.*

- MATH 104 “Calculus 2,” University of Pennsylvania, Fall 2010, Fall 2011. Worked as one instructor of a team of several instructors focusing on the basics of integration theory, differential equations and series. My particular take on this standard course encourages students to understand real-world applications of these topics.

- MATH 313/513 “Computational Linear Algebra,” University of Pennsylvania. Worked as the sole instructor: Spring 2009. This course introduced students to the topics of standard linear algebra, with a focus on numerical and automatic computation. The MATH 513 cross-listing provided an opportunity for more advanced students to explore some of the less-traditional and more technical aspects of the theory.

- MATH 114 “Calculus II,” University of Pennsylvania. Worked as a teaching assistant: Fall 2008. Duties involved issuing and grading weekly quizzes, periodic exams, holding recitations and office hours.

- MATH 293 “Differential equations for engineers,” Cornell University. Worked as a Teaching Assistant: Spring 2006, Spring 2005, Fall 2004. Duties involved grading weekly homeworks, quarterly exams, holding weekly recitations, and office hours. I was nominated for the 2006 Department of Mathematics Teaching Award for my work in this course.

- MATH 191 “Calculus For Engineers,” Cornell University. Worked as an Assistant Lecturer: Fall 2005. Duties involved lecturing three fines a week, writing and grading exams, and holding weekly office hours.

- “Introduction to MATLAB MEX programming,” Syracuse Research Corporation, Summer 2005. Taught an informal in-house company training session.

Conferences Attended:

- IMA workshop on Topological Systems, March 2014, Minneapolis, MN

- Applied Topology, July 2013, Bedlewo, Poland

- SampTA 2013, July 2013, Bremen, Germany

- AMS Sectional Meeting, October 2012, Akron, OH

- MAA MathFest 2012
- NOLTA 2011, September 2011, Kobe, Japan
- IMA Summer school on Applied Topology, July 2011, Philadelphia, PA
- NMMC 2011, May 2011, Madison, WI
- FFT 2011, February 2011, College Park, MD
- ATMCS IV, June 2009, Muenster, Germany
- GETCO 2010, January 2009, Aalborg, Denmark
- PASSHEMA Conference, March 2008, Mansfield, PA
- Joint Mathematics Meetings, January 2008, San Diego, CA
- Workshop in Dynamical Systems, October 2007, Penn State University
- Workshop in Geometric Combinatorics, June 2005, MSRI, Berkeley, CA
- Antennas and Propagation Symposium, June 2004, Monterey, CA
- Applied Computational Electromagnetics Symposium (ACES), April 2004, Syracuse, NY
- AMS/MAA Joint Meetings, January 2003, Baltimore, MD
- AMS/MAA Joint Meetings, January 2002, San Diego, CA

Miscellaneous Awards and Honors:

- Employee Excellence Award from SRC, December 2010, December 2012
- Received first place in the RPI Embedded Control Invitational competition Spring 2000
- Rensselaer Medal (awarded to the top student in mathematics and science in graduating high school class)
- National Honor Society
- Eagle Scout as of 24 April 1997
- Volunteer Computer Mentor (C programming), Grade 9-12

Hobbies and Interests:

Computers and electronics (see below); amateur radio (extra class), callsign KB1DDS; gardening; camping; backpacking; sailing; bookbinding; cooking

Electronics Skills: (*See my website for more detail*)

- Designed, built, and operates a system for collecting acoustic ranging data to drive-test topological signal processing concepts as well as traditional SONAR image formation and exploitation

- Designed and built several different simple computers from 7400-series logic gates
- Restored nonfunctional DEC minicomputers to working condition: PDP-11/45, PDP-11/03, VAX 8530
- Proficient in ANSI Standard C/C++, MATLAB, Python, Scheme, assembly (Intel, Microchip PIC, Motorola 68k, PDP-11), IEEE Verilog, LaTeX, HTML
- Familiar with Haskell, Common Lisp, Fortran, Java, DCL, Pascal

References: available upon request.