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
- Graduated Tolland High School in June 1998, Salutatorian

Publications:

- " Construction of eternal solutions for a semilinear parabolic equation," *Electron. J. Diff. Eqns.*, Vol. 2008(2008), No. 139, pp. 1-8.
- "An asymptotic-numerical approach for examining global solutions to an ordinary differential equation," `arXiv:0709.4664`, which examines existence and uniqueness of global solutions to the nonlinear ODE, $0 = u'' - u^2 + \phi(x)$ using geometric and topological techniques. (Accepted for publication in *Ergodic Theory and Dynamical Systems*.)
- "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.
- "A wavefront launching model for predicting channel impulse response," *ACES Journal*, vol. 22, no. 2, July 2007, pp 302-305.
- "Polarizing frequency of a fluid plasma antenna element," *IEEE Antennas and Propagation Society Symposium*, 2004.

Preprints:

- "A cell complex structure for the space of heteroclines for a semilinear parabolic equation," which shows that the space of heteroclines for a certain parabolic equation has a cell complex structure with finite dimensional cells.
- "Classification of connecting solutions of semilinear parabolic equations," `arXiv:0709.2705`, which provides a strong characterization of solutions that tend to equilibria using an energy functional. Additionally, it shows that the convergence to the equilibria is very regular – uniform convergence on compact subsets for both the solution and its first derivatives.
- "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.

Selected Talks:

- "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.

Courses taught:

- 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:

- 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

Current Research:

I am currently pursuing several topics that lie in the intersection of topology with applied mathematics and analysis. One such project stems from my dissertation research, in which I am examining the global behavior of solutions to semilinear parabolic equations with certain polynomial nonlinearities. The primary technique has been to exploit the similarities and differences of parabolic equations with systems of ordinary differential equations. For instance, a critical point of a parabolic equation whose linearization is stable need not be stable itself. In this case, undestanding the topology of the (infinite dimensional) stable and unstable manifolds for the critical point is essential.
Much of my other work involves the use of algebraic topology to make inroads into difficult signal-processing and imaging problems. For instance, the propagation of the fundamental solution of the wave equation induces a cell complex decomposition of spacetime. This decomposition encapsulates a large amount of information about the topology and geometry of the propagation environment and permits the exploitation of noise-robust, coarse multipath information in mapping and localization.

Research Outlook:

The powerful tools of algebraic and differential topology have yet to be fully applied to the field of nonlinear partial differential equations. Readily apparent are Floer's and Perelman's triumphs of nonlinear analysis in topology. It stands to reason that topology should also inform analysis. For instance, my work on nonlinear parabolic equations is revealing an intimate connection to Morse theory, through the vehicle of Floer homology. Additionally, the examination of nonlinear elliptic equations is still in its infancy, insofar as its connection to topology is poorly understood. This is part of a larger trend which I am helping to create: namely that of using powerful algebraic topological tools to provide deep results in analysis and engineering.

Areas of Interest and Expertise:

- Mathematical
  - Global analysis of parabolic PDE, in particular the use of maximum and comparison principles and Morse theory and symplectic Floer homology
  - Global analysis of nonlinear ODE (smooth dynamical systems), especially topological methods
  - Differential geometry, especially as it relates to PDE; general relativity and Ricci flow are of particular interest
  - Algebraic topology, especially as it relates to signal processing and imaging methodologies
- Engineering
  - Electromagnetic wave propagation in fluid plasma, over terrain, or in complex urban geometries.

  - Spotlight mode Synthetic Aperture Radar (SAR) image formation, geolocation, interferometry
  - General software and digital design

Electronics Skills:

- Designed and built a simple computer from 7400-series logic gates
- Restored nonfunctional DEC minicomputers to working condition: PDP-11/45, PDP-11/03, VAX 8530

Computer Skills:

- Proficient in ANSI Standard C/C++, MATLAB, Scheme, assembly (Intel, Microchip PIC, Motorola 68k, PDP-11), IEEE Verilog, LaTeX
- Familiar with Haskell, Common Lisp, Fortran, Java, DCL, Pascal
- Experienced in computer hardware and networking (PC, Unix, DEC systems)
- Experienced in various Unix operating systems (Linux, *BSD, Mac OS X, Solaris, IRIX, AIX), Windows, VMS
- Experienced in ProEngineer, Unigraphics, Mastercam, CADKEY, SolidWorks

Work Experience:

- Postdoctoral researcher at University of Pennsylvania, PA (July 2008-present).
- 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.
- Syracuse Research Corporation, Syracuse, NY (June 2003-present). Worked on a variety of engineering projects, including
  - Over-land and urban radio propagation modeling
  - Frequency allocation, radio network planning and validation
  - GPS and low-profile antenna design
  - Phased array antenna element measurement and calibration
  - Synthetic aperture radar (SAR) imaging
    * SAR image formation
    * SAR spread-spectrum tag simulation, geolocation, and decoding
    * SAR image exploitation, largely involving coherent change detection
- 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.

Miscellaneous Awards and Honors:

- 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; amateur radio extra; gardening; camping; backpacking; sailing; bookbinding; cooking

Thesis committee:

John Hubbard (chair), John Guckenheimer, Timothy Healey, Alex Vladimirsky

Further references: available upon request.