

# M1 : Verification and Control of Nonlinear and Hybrid Systems


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Theory, algorithms and tools based on viability theory and Hamilton-Jacobi equations. In addition to the material covered in last year's successful course, we will examine verification and hybrid systems in more depth.

Rough outline of topics:

1. Concepts
  - a. Mathematical modeling
  - b. Difference and differential equations
  - c. Optimal control
  - d. Verification
  - e. Differential inclusions
  - f. Viable and related sets
  - g. Discrete time viable sets
  - h. Disturbance inputs, non-determinism and robustness
2. Characterizing the Solutions
  - a. Dynamic programming
  - b. Hamilton-Jacobi equations for optimal control
  - c. Hamilton-Jacobi equations for verification
  - d. Set valued analysis
  - e. Characterization of the viable and related sets
  - f. Optimal control using viability theory
3. Numerical algorithms and tools
  - a. General computational approaches
  - b. Numerical approximations for the Hamilton-Jacobi equation
  - c. Numerical set valued analysis
  - d. Alternative algorithms for verification and control
4. Applications, including
  - a. Mobile Century: capturing highway congestion
  - b. Autonomous underwater robotics
  - c. Optimal robotic path planning
  - d. Aircraft collision avoidance

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<p>Alexandre M. Bayen received the B.S. degree in applied mathematics from the Ecole Polytechnique, Palaiseau, France, in 1998, the M.S. degree in aeronautics and astronautics from Stanford University in 1999, and a Ph.D. in aeronautics and astronautics from Stanford University in 2004. He was a visiting researcher at NASA Ames from 2001 to 2003. From 2004 to 2005, he worked for the French Department of Defense, where he held the rank of Major. During that time, he was the Research Director of the Laboratoire de Navigation Autonome within the Laboratoire de Recherches Balistiques et Aérodynamiques in Vernon, France. Since March 2005 he has been an Assistant Professor in the Department of Civil and Environmental Engineering at the University of California at Berkeley. His research interests include control of distributed parameter systems, mobile sensing, inverse modelling, hybrid systems and air traffic automation.</p>		<p>Ian M. Mitchell received a B.A.Sc. in engineering physics and an M.Sc. in computer science from the University of British Columbia, Canada in 1994 and 1997 respectively, and a Ph.D. in scientific computing and computational mathematics from Stanford University in 2002. After spending a year as a postdoctoral researcher in the Department of Electrical Engineering and Computer Science at the University of California, Berkeley and the Department of Computer Science at Stanford, Dr. Mitchell joined the faculty in the Department of Computer Science at the University of British Columbia as an Assistant Professor in August, 2003. He was the recipient of a 1999 SIAM/AAAS Mass Media Fellowship. He is the author of the Toolbox of Level Set Methods, the first publicly available high accuracy implementation of solvers for dynamic implicit surfaces and the time dependent Hamilton-Jacobi equation that works in arbitrary dimension. His research interests include scientific computing, hybrid systems, verification and robot path planning.</p>	