

M2 : Nonlinear Adaptive Control with Applications

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This course addresses the problem of designing state and output feedback controllers for classes of uncertain nonlinear systems. A new methodology for the design of globally stabilising, adaptive control laws, which is based on the notions of invariant manifolds and system immersion, is developed and applied to numerous practical problems. The method consists in finding a manifold in state -space that can be rendered invariant and attractive with internal dynamics a copy of the desired closed-loop dynamics and then designing a control law that robustly steers the state of the system sufficiently close to this manifold. This two-step approach is in contrast with existing methodologies that rely on the use of control Lyapunov functions. The prominent feature of the proposed approach is that it leads to modular schemes which are easier to tune than their counterparts obtained from Lyapunov redesign. In fact, the resulting closed-loop system can be seen as the cascade or feedback interconnection of stable systems, whose gains can be adjusted to achieve the desired performance. The method is applied to several examples from electrical, mechanical and electromechanical applications, including power converters and electric machines, and the efficacy of the resulting control schemes is verified via numerical simulations and laboratory experiments. In particular, we will discuss case studies on nonlinear adaptive control design for the following applications.

- Controlling the unstable roll motion of an aircraft flying at high angle of attack.
- Output feedback stabilisation of a translational oscillator with a rotational actuator (TORA).
- Autopilot design for autonomous aircrafts.
- Adaptive control of single-phase ACDC converters with power factor correction.
- Output voltage regulation of DC-DC converters.
- Adaptive indirect field-oriented control of induction motors.
- Parameter identification for continuous-time linear systems.
- Range estimation of a moving object from perspective images.



Alessandro Astolfi, was born in Rome, Italy, in 1967. He graduated in electrical engineering from the University of Rome in 1991. In 1992 he joined ETH -Zurich where he obtained an M.Sc. in Information Theory in 1995 and the Ph.D. degree with Medal of Honour in 1995 with a thesis on discontinuous stabilization of nonholonomic systems. In 1996 he was awarded a Ph.D. from the University of Rome for his work on nonlinear robust control. Since 1996 he is with the Electrical and Electronic Engineering Department of Imperial College, London (UK), where he is currently Professor in Nonlinear Control Theory. From 1998 to 2003 he was also an Associate Professor at the Dept. of Electronics and Information of the Politecnico di Milano (Italy) and since 2006 he is also a Full Professor at the Dept. of Computer Science, Systems and Production of the University of Rome "Tor Vergata". He has been visiting lecturer in "Nonlinear Control" in several universities, including ETH -Zurich (1995-1996); Terza University of Rome (1996); Rice University, Houston (1999); Kepler University, Linz (2000); SUPELEC, Paris (2001). His research interests are focused on mathematical control theory and control applications, with special emphasis for the problems of discontinuous stabilization, robust stabilization, robust control and adaptive control. His research activity has been supported by EPSRC (he is currently a member of the EPSRC Control and Power Portfolio Partnership and of the EPSRC-BAE Systems Flaviir Consortium), the Leverhulme Trust, the CEC (he was the Scientist in Charge of the Research Training Network NACO2 and he is a member of the Control Training Site programme). He was awarded the Philip Leverhulme Prize in 2003. The prize is "to recognise the outstanding research achievements of young scholars of distinction and promise based in UK institutions". He is an associate editor for the International Journal of Adaptive Control and Signal Processing (2006-), IEEE Transactions on Automatic Control (2005-), Automatica (2002-), the European Journal of Control (2000-), the International Journal of Control (2000-), and Systems and Control Letters (1998-). He is Fellow of the IEE, Senior Member of the IEEE, Fellow of the WIF, Member of the EPSRC Engineering Panel (2003 -2005). He is a Member of the Council of the European Union Control Association (2006 -) and a Member of the IFAC Technical Committee on Control Design (2004 -). He has also served in the IPC of numerous

	<p>international conferences. A. Astolfi is the author of more than 60 journal papers in top quality international journals, 140 conference papers, 15 book chapters, and two patents on "AC/DC power conversion" and "Waste to energy". He is a co-editor of a book on 'Modelling and control of mechanical systems' (Imperial College Press, 1997), and editor of a book on 'Nonlinear and Adaptive Control' (Imperial College Press, 2005). He has supervised 7 Ph.D. students, 10 postdoctoral research assistants, and more than 30 M.Sc. students.</p>
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