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Editorial

This Special Issue contains seven papers on various aspects of adaptive control. The papers are quite different in nature, however, they share at least one feature: they all study fundamental limitations of adaptive control and propose alternatives.

Short versions of all papers but one were presented during an invited session on adaptive systems at the Fifteenth International Symposium on the Mathematical Theory of Networks and Systems (MTNS) which took place at the University of Notre Dame, South Bend, Indiana, USA, in August 2002. The paper by Sanei and French was presented in a parallel session at the same conference.

Adaptive control has been a highly active field of research in the 1970s and 1980s but as the full extent of the intricate nature of adaptive control problems unfolded research output declined. It is our thesis that despite the significant advances of the past many of the fundamental issues concerning adaptive systems theory, design and practice remain largely unsolved. The papers in this special issue form a modest contribution to re-invigorate the debate and quest to understand learning or adaptation in the context of a closed loop control system.

Below, we briefly discuss each paper separately.

Cautious Hierarchical Switching Control of Stochastic Linear Systems by Campi, Hespanha, and Prandini. This paper is concerned with a switching control view point of adaptive control in which a supervisor decides which controller to implement based on past observations. Rather than selecting the controller in a certainty equivalence fashion, the uncertainty about the model is explicitly taken into account. The uncertainty is modelled probabilistically. It is shown that the supervisor is capable of making an appropriate trade-off between robustness and performance by selecting this controller that minimizes the average cost over the plant uncertainty set. Algorithmic tractability is achieved through means of a randomized algorithm approach.

Strong Robustness in Multi-Phase Adaptive Control: the Basic Scheme, by Cadic and Polderman. Certainty equivalence means that the controller is selected on the basis of the model as if the model represents the true system. The authors propose to distinguish two phases. One where the control action is used to reduce uncertainty and a second phase where the uncertainty has been reduced to a level where a controller can be designed on the basis of the model. To quantify at which level the uncertainty is sufficiently low the notion of a strongly robust uncertainty set is introduced.

Near Optimal LQR Performance for Uncertain First Order Systems, by Luo and Miller. This paper studies adaptive optimal performance. The key idea is to use a periodic controller that is split into an estimation phase and a control phase. The resulting scheme provides near optimal control. For simplicity of presentation the ideas are explained for first order systems only.

Self-Tuning Control for Polynomial Systems Using a Receding Horizon Observer and Control Strategy, by Mareels. In this paper, a class of adaptive control problems is cast into a framework of non-linear control, where all uncertainty about the system is captured by the uncertainty concerning its initial condition. As in the previous two papers, adaptation, which here amounts to reconstruction of the state and (partial) regulation of the system state are then considered as

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two distinct phases in the overall control scheme. These two phases are iterated in a receding horizon fashion to obtain ongoing adaptation and control.

Geometry of Adaptive Control: Optimization and Geodesics, by Colon and Pait. Certainty equivalence adaptive control brings about a nasty side effect: the notorious stabilizability problem. When the model that results from the identification procedure is not stabilizable, a controller cannot be computed. The central observation made in this paper is that a system is stabilizable if and only if an associated Riccati equation has a positive definite solution. The idea to sidestep the stabilizability problem is then to jointly estimate the system parameters and the solution to the corresponding ARE.

Two Scale High Gain Adaptive Control, by Polderman and Mareels. This paper is concerned with the robustification of high gain universal controllers. The paper describes a step by step modification that is somewhat artificial. But the step by step analysis provides strong evidence that the modification contains necessary ingredients only. The paper highlights that the problem of robust adaptive control, even in the context of very simple systems which allow high gain stabilization is not trivial, as there is no obvious way to achieve an appropriate trade-off between asymptotic and transient performance even for this class of systems.

Towards a Performance Theory of Robust Adaptive Control, by Sanei and French. This paper makes a comparison between robust adaptive control schemes based on two techniques: the use of dead-zones and parameter projection. By considering transient performance measures to capture the quality of the adaptive control, the authors demonstrate how prior knowledge determines which of the two methods is to be preferred over the other. The ideas are exemplified in the context of scalar non-linear systems, and discusses how the results may generalize for other classes of systems.

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JAN WILLEM POLDERMAN
Department of Applied Mathematics
University of Twente P.O.Box 217
7500 AE Enschede, The Netherlands
j.w.polderman@math.utwente.nl

IVEN MAREELS
Department of Electrical and Electronics Engineering
The University of Melbourne
Vic 3052 Australia