INTERNATIONAL JOURNAL OF ADAPTIVE CONTROL AND SIGNAL PROCESSING
Int. J. Adapt. Control Signal Process. 2004; **18**:81–82 (DOI: 10.1002/acs.804)

Editorial

Adaptive techniques have been mainstays in automotive control almost since the introduction in the mid 1970s of the embedded microprocessor for engine control. Large production volumes, manufacturing variability, long operational lifetimes over a wide range of operating conditions while achieving stringent emissions and performance objectives have mandated adaptive approaches. Automotive systems have always served as the testbed and demonstration platform, as well as motivational problems, for advanced adaptive control design methodologies. Most of the adaptive algorithms found on production vehicles, albeit heuristic for many applications, have been the result of ingenious implementations of the advanced theoretic development. Standard examples include air–fuel ratio and idle speed control. Today, requirements for advanced safety systems, better fuel economy, improved comfort and convenience, and even lower emissions are driving research and application of adaptive control and signal processing for current and next-generation vehicles. The purpose of this special issue is to examine the impact of adaptive control and signal processing on automotive systems, to review current efforts across a range of applications, and to introduce new results that promise improved performance for advanced vehicle technologies.

The papers included in this special issue cover a wide range of applications, from active suspension to aftertreatment control, and from air conditioning to aircharge estimation. Two papers address estimation and control of vehicle chassis dynamics. The authors of ‘Adaptive Robust Force Control for Vehicle Active Suspension’ apply a modular adaptive robust control (MARC) technique to the design of the force-loop controller for a hydraulic actuator. Experimental results are shown for a quarter car suspension test rig. ‘Real Time Identification of Vehicle Chassis Dynamics Using a Novel Reparameterization Based on Sensitivity Invariance,’ describes the on-line identification of road–tire characteristics using dimensional analysis techniques. The method is demonstrated using a scale vehicle testbed.

The majority of papers in this issue deal with the often-conflicting objectives of improving fuel economy and reducing emissions. ‘Composite Adaptive and Input Observer Based Approaches to the Cylinder Flow Estimation in Spark Ignition Engines’ describes methods of improving air–fuel ratio control for advanced technology engines where significant variation in volumetric efficiency during transient operation may be expected. Such engines might incorporate, for example, variable valve timing, variable geometry turbocharging or continuously variable valve lift. An adaptive algorithm with improved identifiability and convergence rate is presented which combines the tracking error and parameter estimation error in the adaptive law. The authors of ‘Aftertreatment Control and Adaptation for Automobile Lean Burn Engines with HEGO Sensors’ address problems associated with a new generation of engines incorporating a unique catalytic converter referred to as a Lean NO_x Trap (LNT). Here, trap capacity and feedgas NO_x models are adapted to maintain aftertreatment performance despite system changes due to operating condition or age. Homogeneous charge compression ignition engines hold the promise of very low NO_x emissions and diesel-like fuel economy. Good combustion control is essential, however, and ‘Closed-loop Combustion Control of Homogeneous Charge Combustion Ignition (HCCI) Engine Dynamics’ compares several estimation methods for establishing the combustion point corresponding to 50% mass fraction burned. On a conventional spark ignition engine, misfire detection is required for on-line monitoring of emission components. 'Advanced Misfire Detection Using Adaptive Signal Processing,' describes methods based on engine crankshaft angular speed measurements where adaptive disturbance estimation enables more accurate detection. Finally, 'Application of a Multivariable Adaptive Control Strategy to Automotive Air Conditioning Systems' presents a recursive estimation approach to the development of the A/C model used for control.

As we introduce these widely diverse applications, we also note the broad spectrum of the methodologies and techniques incorporated by the authors. Two papers, 'Adaptive Robust Force Control for Vehicle Active Suspension' and 'Composite Adaptive and Input Observer based approaches to the Cylinder Flow Estimation in Spark Ignition Engines,' demonstrate how the performance and robustness of the 'certainty equivalence' based design can be improved through modularization (Chantranuwathana and Peng) and integration of tracking control and parameter estimation (Stotsky *et al.*). In 'Real Time Identification of Vehicle Chassis Dynamics Using a Novel Reparameterization Based on Sensitivity Invariance' and 'Aftertreatment Control and Adaptation for Automobile Lean Burn Engines with HEGO Sensors', new parametrization has enabled the authors to formulate and simplify the problem at hand, and make the non-conventional problems amenable to standard adaptive control and parameter estimation algorithms. For the rest of the papers, while all deal with parameter estimation, the authors adopted different algorithms for their problem-specific requirements. Naik has focused on the periodic disturbance removal for the misfire detection problem using adaptive filtering, Bengtssen *et al.* have concentrated on identifying algorithms feasible for cycle-to-cycle feedback control, and Shah *et al.* have resorted to standard least-squares estimation for solving their multi-input multi-output adaptive control problem.

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