Ph.D Short Course on

Sustainable Automotive Powertrain System Control Design

March 23-30, 2017, Sophia University, Tokyo, Japan

The short course aims to introduce basic knowledge on system control theory and application in sustainable automotive powertrain systems. The topics include dynamical system control theory, especially stochastic optimal control, model predictive control, and its application in developing advanced automotive powertrain control systems. During the course, an interactive poster session and round table discussion will be organized for the attenders. A benchmark problem on engine boundary control will be reviewed and provided by industrial researcher.

Lecturers:

Junmin Wang, Professor, Ohio State University, USA
Per Tunestål , Professor, Lund University, Sweden
Mazen Alamir, Professor, Grenoble University, France
Yuhu Wu, Professor, Dalian University of Technology, China
Alex Ohata, Seiner Adviser, TECHOVA, Japan

Prospective Participants*

Ph.D course students from any Japanese universities including MIRAI partners (Master's students are also welcome)

Ph.D course students from Swedish MIRAI partners

*1) The participants are required to register in advance by e-mail;
*2) The Participant who intends to contribute a Poster Presentation, please send your title and abstract in advance.

Organizer

Sophia University

Co-Sponsor

MIRAI

- Connecting Swedish and Japanese Universities through Research, Education and Innovation

Steering Committee

Tielong Shen
(Professor, Sophia University, Japan)

Lars Eriksson
(Professor, Linkoping University, Sweden)

Per Tunestål
(Professor, Lund University, Sweden)

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Program at a Glance

Time Schedule	10:00-12:00	13:30-15:00	15:15-17:00
3/23 THU		• Registration	• Registration
3/24 FRI	• Engine Combustion Control I Per Tunestal (Lund University)	• Engine Combustion Control II Per Tunestal (Lund University)	• Benchmark Problem A. Ohata (Technova)
3/25 SAT	• Optimal Control for Stochastic Logical Networks and Its Applications I Prof. Yuhu Wu (Dalian University)	• Optimal Control for Stochastic Logical Networks and Its Applications II Prof. Yuhu Wu (Dalian University)	• LabTour
3/26 SUN	• Estimation and Control of Conventional and Electrified Powertrain and After-treatment Systems I Prof. Junmin Wang (Ohio State Univ.)	• Estimation and Control of Conventional and Electrified Powertrain and After-treatment Systems II Prof. Junmin Wang	• Poster Session
3/27 MON	• Estimation and Control of Conventional and Electrified Powertrain and Aftertreatment Systems III Prof. Junmin Wang (Ohio State Univ.)		
3/28 TUE	• Model Predictive Control and Optimization I Prof. M. Alamir (Grenoble University)	• Model Predictive Control and Optimization II Prof. M. Alamir (Grenoble University)	• Round Table Discussion on Benchmark Problem
3/29 WED	• Model Predictive Control and Optimization III Prof. M. Alamir (Grenoble University)	• Round Table Discussion on Automotive Industry	

Tutorial Lecture I:
Estimation and Control of Conventional and Electrified Powertrain and Aftertreatment Systems

Junmin Wang
Professor, Ohio State University;
Director, Vehicle Systems and Control Laboratory, USA

Abstract: This short course aims to introduce modeling, estimation, and control system designs for conventional and electrified powertrain and aftertreatment systems. Combinations of powertrain and aftertreatment system physical characteristics with control/estimation theories will be emphasized through examples generated from a range of pertinent research projects and papers. The course will contain the following series of lectures.
Module I (2 hours): Control-oriented modeling for engine and aftertreatment systems. This module will describe various physics-based and control-oriented models for engine systems and exhaust aftertreatment devices.
Module II (2 hours): Estimation and control systems for engine and aftertreatment systems. Grounded in the control-oriented models, various estimation and control approaches for both conventional and electrified powertrain and exhaust aftertreatment systems will be introduced.
Module III (2 hours): Integrated and optimal control for conventional and electrified powertrain-aftertreatment systems. With the intertwined dynamics of engine, electric drive, and aftertreatment systems, integrative and optimal powertrain-aftertreatment control systems for overall vehicle energy consumption and tailpipe emission reductions will be explained through several examples. Incorporations of human factors and connected vehicle technologies on powertrain-aftertreatment system control will be included as well.

Junmin Wang joined Ohio State University and founded the Vehicle Systems and Control Laboratory in September 2008. He was early promoted to Associate Professor in September 2013 and then very early promoted to Full Professor in June 2016. He gained five years of full-time industrial research experience at Southwest Research Institute (San Antonio Texas) from 2003 to 2008. Prof. Wang has a wide range of research interests covering control, modeling, estimation, optimization, and diagnosis of dynamical systems, especially for automotive, vehicle, sustainable mobility, human-machine, and cyber-physical system applications. Prof. Wang's main research contributions embrace the development of control and estimation methods that can advance efficiency, cleanliness, and driving safety of conventional, electrified, automated and connected vehicles. Dr. Wang is the author or co-author of more than 250 peer-reviewed publications including 124 journal articles and 11 U.S. patents. He has served or currently serves as a Senior Editor/Editor/Technical Editor/Associate Editor for seven journals and Chair of several technical committees in various professional societies. Prof. Wang is a recipient of the 2017 IEEE Transactions on Fuzzy Systems Outstanding Paper Award, 2015 Ohio State University Harrison Faculty Award for Excellence in Engineering Education, National Science Foundation CAREER Award, Ohio State University Lumley Research Award, and SAE Ralph R. Teetor Educational Award in 2012, as well as the SAE International Vincent Bendix Automotive Electronics Engineering Award and Office of Naval Research Young Investigator Award (ONR-YIP) in 2009. He was elected IEEE Vehicular Technology Society Distinguished Lecturer in 2015, Fellow of the Society of Automotive Engineers (SAE) in 2015, and Fellow of the American Society of Mechanical Engineers (ASME) in 2016.
Dr. Wang received the B.E. in Automotive Engineering and his first M.S. in Power Machinery and Engineering from the Tsinghua University, Beijing, China in 1997 and 2000, respectively, his second and third M.S. degrees in Electrical Engineering and Mechanical Engineering from the University of Minnesota, Twin Cities in 2003, and the Ph.D. degree in Mechanical Engineering from the University of Texas at Austin in 2007.

Tutorial Lecture II: Engine Combustion Control

Per Tunestål
Professor, Lund University, Sweden

Abstract: Combustion control is the art of achieving a desired combustion specification in real time using the available actuators, sensors and computational hardware. Traditionally, combustion control is primarily based on maps with engine speed and load as independent variables but modern combustion concepts as well as ever stricter emission standards require closed loop control of the combustion process based on sensors both inside and outside the combustion chamber.
The lecture includes a brief overview of conventional and advanced engine combustion concepts and their respective control requirements. An overview of available sensors and actuators is presented as well as methods to extract combustion information from the sensors. Application examples from SI, Diesel, HCCI and PPC control are included in order to present a comprehensive picture of sensing, computation, actuation and the result on combustion and performance. Various control design methods are covered in light of the examples, such as PID, LQG, MPC and mid-ranging. Adequate gas path control is a prerequisite for combustion control and is also covered in the module.

Per Tunestål received his PhD in Mechanical Engineering at the University of California, Berkeley in 2000. He presently holds a position as Professor at Lund University where he is in charge of the engine control activities. Per Tunestal also serves as Director of The KCFP Engine Research Center, a consortium financed by The Swedish Energy Agency, Lund University and 14 member companies world-wide. Special interests are engine control based on in-cylinder measurements and cylinder-pressure based parameter estimation. Per Tunestal holds more than 100 scientific publications within the combustion engine field and he has served as chairman of the Control and Calibration committee within the Society of Automotive Engineers. Lund university was founded in 1666. Today it is an international center for research and education that has approximately 48 000 students and 7500 employees. Lund University is respected as one of the top universities in Sweden with an excellent academic reputation and a large number of visiting professors and international students. Lund University is also consistently ranked as one of the top 100 universities in the world.

Tutorial Lecture III: Model Predictive Control and Optimization

Mazen Alamir
Professor, Grenoble University, France

Abstract: Model Predictive Control (MPC) is a control design methodology that gained tremendous success because of its ability to handle multi-variable, constrained nonlinear system as well as optimality concerns. The theoretical foundation of nominal MPC design is now fully understood. Nevertheless, several implementation issues are still an active research area. Among them, the real-time implementation on fast systems and the distributed/hierarchical implementation are two main issues that need further investigation. This course is divided into three modules:

Module 1: Basic MPC design (Stability theory)

Module 2: Real-Time implementation

Module 3: Hierarchical Implementation of MPC

Many examples from academic and industrial contexts are used to illustrate the concepts included in the course.

Mazen Alamir graduated in Mechanics (Grenoble, 1990) and Aeronautics (Toulouse, 1992). He received his Ph.D. in Nonlinear Model Predictive Control in 1995. Since 1996, he has been a CNRS Research Associate in the Control Systems Department of Gipsa-lab, Grenoble. His main research topics are model predictive control, receding horizon observer, nonlinear hybrid systems, signature based diagnosis and optimal cancer treatment as well as industrial applications. He is member of the IFAC technical committee on Nonlinear Systems and served as head of the ''Nonlinear Systems and Complexity'' research group of the Control Systems Department of Gipsa-lab, Grenoble. Home page: www.mazenalamir.fr

Tutorial Lecture IV: Optimal Control for Stochastic Logical Networks and Its Applications

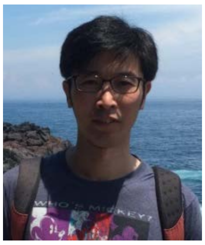
Yuhu Wu
Professor, Dalian Institute of Technology, China

Abstract: In the last two decades, logical networks have been observed in various applications such as systems biology, power grids, combustion engines, game theory, encryption, robotics and various other areas. The essential feature of the logical dynamical system (logical network) is that the state variable is defined in a logic domain, and the logic domain usually consists of a finite or a countable infinite logic states. For such kind of systems, analysis and synthesis under a logical dynamical system framework usually leads to simple logical control law. Therefore, the logic-based control becomes a hot topic in the control community.

This short lecture includes a brief overview of logical networks and its algebraic state space formulation. The optimal control problems (include infinite horizon and finite horizon) for the stochastic logical networks will be introduced. The value iteration algorithm and policy iteration algorithm will be presented. Some applications to engine control problems will be given in final.

Module I: Brief overview of the analysis and control of logical networks

Module II: Optimal control design for stochastic logical networks



Yuhu Wu received the Ph.D. degree in Mathematics from the Harbin Institute of Technology, Harbin, China, in January, 2012. Since September, 2012 he has held an assistant professor position at Harbin University of Science and Technology, China. He held a postdoctoral research position at Sophia University, Japan, 2012–2015. He joined Dalian University of Technology at 2015, where he is now an Associate Professor of School of Science of Engineering. His research interests are related to nonlinear control theory, distributed parameter systems, logical systems, and stochastic process.

Tutorial Lecture V: Benchmark Problem of Engine Control

Alex Ohata
Seiner Adviser, TECHOVA

Abstract: *To be updated…*

Alex Ohata graduated from Tokyo Institute of Technology in 1973 and directly joined Toyota Motor Corporation. He was involved in exhaust gas emissions control, intake and exhaust system developments, variable intake systems, hybrid vehicle control, vehicle controls, Model-Based Development (MBD), and the education of advanced control theory at Toyota. He was also involved in the standardization activity assuring dependability of consumer devices in Object Management Group (OMG). He was a senior general manager of Toyota Motor Corporation when he retired from Toyota in 2015. He was a research fellow of Information Technology Agency (IPA) under the Ministry of Economy, Trade, and Industry. Now, he is a seiner adviser of TECHOVA, an advisor of MathWorks Inc., a member of mathematical cooperation program under the ministry of education, culture, sports, science and technology, and an industry vice chair of IFAC TC7.1 (automotive control). His current major interest is modeling that includes model simplification and the integration of physical and empirical models. He received the most outstanding paper award in convergence 2004, the technical contribution award from JSAE in 2006, the outstanding paper award from SICE (Society of Instrument and Control Engineers) in 2014 and 2016.