Model Predictive Control Design and Implementation Using MATLAB®

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Workshop Outline: Model Predictive Control (MPC) has a long history in the field of control engineering. It is one of the few areas that has received on-going interest from researchers in both the industrial and academic communities. Three major aspects of model predictive control make the design methodology attractive to both engineers and academics. The first aspect is the design formulation, which uses a completely multivariable system framework where the performance parameters of the multivariable control system are related to the engineering aspects of the system; hence, they can be understood and 'tuned' by engineers. The second aspect is the ability of method to handle both 'soft' constraints and hard constraints in a multivariable control framework. This is particularly attractive to industry where tight profit margins and limits on the process operation are inevitably present. The third aspect is the ability to perform process on-line optimization.

This one-day short-course gives an introduction to model predictive control, and recent developments in design and implementation. Beginning with an overview of the field, the course will systematically cover topics in optimization, receding horizon control, MPC design formulations, constrained control, as well as real time simulation and implementation using MATLAB® and Simulink® as a platform. The simulation and implementation procedures are demonstrated on a magnetic bearing system. The course is suitable for engineers, students and researchers who wish to gain basic knowledge about model predictive control, as well as understand how to perform real time simulation and implementation using MATLAB and Simulink tools. MATLAB and Simulink programs for MPC design and simulation, written by the lecturers, are available to the participants of the workshop.

Workshop Schedule

8.30 - 10.30: Introduction to Model Predictive Control

Course overview; state-space models; design formulation using velocity form model and design formulation using a general state space model; set-point following and disturbance rejection of ramp signals and sinusoidal signals; state estimation.

10:45-12:45: Model Predictive Control using Laguerre and Kautz functions

Exponential data weighting in MPC design with guaranteed stability margin and numerically well-conditioned algorithms; MPC design using Laguerre functions and Kautz functions; Equivalence between MPC and Linear Quadratic Regulator (LQR) when using Kautz functions.

13:45-15:30 Constrained Model Predictive Control

Formulation of the constrained control problem; solution to the constrained control problem via identification of active constraints; feasibility; stability; simplified solutions.

15:45-17:30 Real Time Simulation and Implementation of Model Predictive Control on a Magnetic Bearing System

Magnetic bearing system; real time simulation using MATLAB and Simulink; real time implementation using MATLAB and Simulink; experimental test.

About the Lecturers:

Dr Liuping Wang received her Ph.D degree in 1989 from the Department of Automatic Control and Systems Engineering, University of Sheffield, UK. Upon completion of her PhD degree, she worked in the Department of Chemical Engineering at the University of Toronto, Canada for eight years in the field of process control. From 1998 to 2002, she worked in the Center for Integrated Dynamics and Control, University of Newcastle, Australia. In February 2002, she joined the School of Electrical and Computer Engineering, RMIT University, Australia where she is a Professor of Control Engineering and the Head of Discipline for Electrical Energy and Control Sysems. She has authored and co-authored more than 100 scientific papers in the field of system identification, PID control, adaptive control, model predictive control, and control technology application to industrial processes. She co-authored a book with Professor Will Cluett entitled *From Process Data to Process Control- Ideas for Process Identification and PID control* (Taylor and Francis, 2000). More recently, she co-edits a book with Professor Hugues Garnier entitled ' *Continuous time model identification from sampled data*' (to be published by Springer-Verlag in 2007). Her new book entitled ' *Model Predictive Control Design and Implementation using MATLAB®*' will be published by Springer-Verlag in 2007. Dr Liuping Wang has successfully applied the predictive control technologies to food extruders, automotive brake-by-wire systems, and magnetic bearing systems. She currently works on design and implementation of high performance predictive control systems for the next generation of CNC machines.

Dr Rossiter recieved his first degree (1987) and D.Phil (1990) from Engineering Science at the Oxford University. He took up his first academic post at Lougbourough University in 1992 and subsequently moved to the Department of Automatic Control and Systems Engineering at the University of Sheffield in 2001. His main interest throughout this time has been predictive control and thus he has been involved in some of the key developments within the field. In particular his contributions (with co-workers) to understanding stability and feasibility issues through dual mode prediction structures are now widely adopted. More recently his interests have been in computational efficiency, insight and simplicity, that is, how do you get the most out of a simple predictive control algorithm? In parallel, Dr Rossiter also has a large interest in and commitment to the quality enhancement of university level engineering education.