Advanced Control Fundamentals Course

Multivariable, Optimal, Robust and Predictive Control Systems Design

Three-day Course, 12th - 14th November, Glasgow

This course is new and was designed for control specialists or to advance the learning for those that have attended the Control Fundamentals courses. It covers a range of advanced control topics in an overview and introductory form describing some of the most important problems in control design and applications:

- Modern modelling and simulation methods.
- Optimal Control and Optimisation Techniques
- Dealing with Uncertainty
- Robust and Safety Critical Control Methods
- Predictive Control to Handle Constraints
- Nonlinearities and Design Issues
- Application of Advanced Control Problems & Solutions

AGENDA

Day 1: Introduction to Modelling, Multivariable and Optimal Control

L1.0: 09.00-09.15: Introduction to the Course

L1.1: 09.15-10.15: Modelling of Dynamic Systems

(Modelling of linear and nonlinear systems to be controlled, model requirements, state space models, benefits of simulation).

10.15 Tea / Coffee

L1.2: 10.30-11.30: Kalman Filters and Observers for State Estimation

(Optimal estimation problems and Kalman filtering algorithms or observers for linear, time-varying and LPV systems, and for use in MPC control solutions).

H1: 11.30-12.30: Hands-on Session: State Estimation for Systems

(Powertrain Example, Stochastic Systems, State estimation using Kalman Filter, Observers)

12.30 - 13.30: Lunch

L1.3: 13.30-14.15: Introduction to Multivariable Control Design and Stability

(Multivariable system models, Model Structures and Compensation, Relative Gain Array, Stability)

14.15 Tea / Coffee

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L1.4: 14.30-15.30: Introduction to LQ and LQG Optimal Control

(Optimal Control Techniques for Linear Systems, Optimal control cost-functions, LQ control, LQG control, Natural Robustness properties)

H2: 15.30-16.15: Hands-on Session: LQ State Feedback Optimal Control and Robustness Properties

(Flight Control Example, Gain & Phase Margins of state feedback solutions)

L1.5: 16.15-17.00: Design Example Using LQG Control

(Thickness control, Kalman filtering and LQG design example)

17.00 Close

Day 2: Introduction to Uncertainty and Robust Control

L2.1: 09.00-10.00: Uncertainty in Systems and Robustness

(Modelling uncertainty, control design in presence of uncertainty).

10.00 Tea / Coffee

H3: 10.15-11.15: Hands-on Session: LQG Stochastic Control Design

(Flight Control Example, Disturbance Rejection, Robustness, use of Dynamic Cost-Function Weightings)

L2.2: 11.15-12.15: Introduction to Robustness and H∞ Control

(H∞ cost measures, Standard system model control structures with uncertainty).

12.15 - 13.15: Lunch

H4: 13.15-14.15: Hands-On Session: Robustness and H_∞ Robust Control System Design

(F16 flight control H∞ design example)

L2.3: 14.15-15.15: Design Example Using Kalman Filtering, LQG, H_∞ Methods

(Modelling, estimation and LQG or H∞ design stages, and results, using a positioning control design example)

15.15: Tea / Coffee

L2.4: 15.30-16.00: Quantitative Feedback Theory Robust Control Design Method

(frequency response based robust control design method, design example remote pilotless vehicle)

L2.5: 16.00-17.00: Introduction to Linear Model Predictive Control

(Optimal constrained and unconstrained control, operation of basic algorithms, pros and cons).

17.00 Close

Day 3: Predictive and Nonlinear Control Systems Design

L3.1: 09.00-10.00: Model Predictive Control: with Linear Parameter-Varying Models
(Use of linear parameter varying models to approximate nonlinear systems).

10.00 Tea / Coffee

L3.2: 10.15-11.00: Optimisation and Quadratic Programming Solvers
(Convex optimisation problems, Use in MPC design).

H5: 11.00-12.00: Hands-on Session: Introducing Model Predictive Control Design Approach and Performance Results
(vehicle suspension control problem)

12.00 - 13.00: Lunch

L3.3: 13.00-14.00: Overview of Nonlinear Control Techniques
(The range of nonlinear control design options available)

H6: 14.00-15.00: Hands-on Session: Introducing Nonlinear Control System Problems and Design Methods

15.00: Tea / Coffee

L3.4: 15.15-16.00: Servo System Design Study: for Nonlinear Control Design Applications
(Sightline Stabilisation of Electro-Optical Devices)

L3.5: 16.00-16.50: Model Based Advanced Control Methods
(Summary of Important Features of Model Based Design Methods Covered in the course and Recent Developments).

16.50 - 17.00: End of Course Questions and Close