Engineering Tripos Part IIB, 4F3: An Optimisation Based Approach to Control, 2021-22

Module Leader and lecturer
Prof G Vinnicombe [1]

Lecturer
Prof G Vinnicombe, Dr F Forni [2]

Timing and Structure
Lent term. 14 lectures + 2 examples classes, Assessment: 100% exam

Prerequisites
3F1 and 3F2 useful

Aims
The aims of the course are to:

- introduce methods for feedback system design based on the optimization of an objective, including reinforcement learning and predictive control.
- demonstrate how such control laws can be computed and implemented in practice.

Objectives
As specific objectives, by the end of the course students should be able to:

- understand the derivation and application of optimal control methods.
- appreciate the main ideas, applications and techniques of predictive control and reinforcement learning.

Content
Optimal Control (7L + 1 examples class, Dr F Forni)

- Formulation of convex optimisation problems
- Status of theoretical results and algorithms
- Formulation of optimal control problems. Typical applications
- Optimal control with full information (dynamic programming)
- Control of Linear Systems with a quadratic objective function
- Output feedback: ‘LQG’ control
- Control design with an “H-infinity” criterion

Predictive Control and an Introduction to Reinforcement Learning (7L + 1 examples class, Prof G Vinnicombe)
What is predictive control? Importance of constraints. Flexibility of specifications. Typical applications
Basic formulation of predictive control problem without constraints and the receding horizon concept.
Including constraints in the problem formulation. Constrained convex optimization
Terminal conditions for stability
Emerging applications: advantages and challenges
Policy and generalized policy iteration; rollout algorithms and predictive control
Approximate dynamic programming
Deep neural nets as universal approximators for value and policy.
Simulation based vs state space models - Q learning.

Booklists
Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines
Please refer to Form & conduct of the examinations [3].

Last modified: 20/05/2021 07:49

Source URL (modified on 20-05-21): http://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iib-4f3-optimisation-based-approach-control-2021-22

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