

## **Engineering Tripos Part IIB, 4F3: An Optimisation Based Approach to Control, 2019-20**

### **Module Leader and lecturer**

[Dr G Vinnicombe](#) [1]

### **Lecturer**

[Dr G Vinnicombe, Dr F.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, Dr 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. Comparison with unconstrained Linear Quadratic Regulator
- 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 see the [Booklist for Group F Courses](#) [3] for references for this module.

### Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [4].

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### Links

[1] <mailto:gv103@cam.ac.uk>

[2] <mailto:gv103@cam.ac.uk>, [ff286@cam.ac.uk](mailto:ff286@cam.ac.uk)

[3] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=55891>

[4] <https://teaching.eng.cam.ac.uk/content/form-conduct-examinations>