Engineering Tripos Part IIA, 3F2: Systems & Control, 2018-19

Module Leader

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Timing and Structure

16 Lectures, Lent Term

Aims

The aims of the course are to:

- make students familiar with “state-space” methods of modelling and analysing dynamic systems. These methods are extremely important for control engineering, signal processing, and related subjects.

Objectives

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

- understand what a state-space model is, and how to obtain such a model;
- relate state-space models to transfer-function models;
- analyse the behaviour and structure of a state-space model;
- have some understanding of feedback design using state-space, transfer function and root-locus techniques, and be able to relate them to each other;
- appreciate the need for and usefulness of state observers, and their role in feedback and other systems.

Content

State-space models (6L)

- Review of second-year material (linear algebra, transfer functions, poles)
- Formulation from physical models
- Linearising nonlinear models
- Relationship to transfer function matrix (multiple inputs/outputs)
- Free and forced responses (state-transition matrix convolution, stability)
- Interconnections of systems

Feedback system design (4L)

- Review of second-year material (feequency responses, controller structures, objectives of feedback

design).
- The root-locus diagram
- Routh-Hurwitz criterion (examples of use).

State estimation (3L)

- Observability.
- State observer; Oberver design.
- Connections to Kalman filters, sensor fusion etc.

Control in state-space framework (3L)

- Controllability.
- State feedback and pole-placement.
- Optimal control.
- State observer combined with state feedback

Examples papers

Paper 1: State-space models - issued in week 3
Paper 2: Root locus - issued in week 5
Paper 3: Observers and state feedback - issued in week 7

Coursework

Inverted pendulum experiment (state feedback). Laboratory report and/or full technical report.

Ball and beam experiment (state trajectories, nonlinear control). Laboratory report only.

Learning objectives:

- State feedback
- Pole placement
- Control design

Practical information:

- Sessions will take place in EIETL laboratory, on Wednesdays and Fridays of full term
- Students will find it helpful to read through the lab sheet in advance of carrying out the experiment.).

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the **Booklist for Part IIA Courses** [2] for references for this module.

Examination Guidelines

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

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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Links
[1] mailto:gv103@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=48931
[3] https://teaching19-20.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching19-20.eng.cam.ac.uk/content/uk-spec