Advanced Control Systems

Course Introduction

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Course & Module Organizer

Timetable:

- 1 weekly lecture (2 hrs)
  - Time: Wednesdays - 10:00 to 12:00
  - Room: Graduate Ctr - GC601 Montagu LT
  - Start date: Week 1 - 22/01/2025
- 1 weekly tutorial class (1 hr)
  - Time: Wednesdays - 9:00 to 10:00
  - Room: Eng - B10 - IoC Lab
  - Start date: Week 2 - 29/01/2025

Contact Information:

- Dr. Aidan Hogg (Module Organizer)
  Email: `a.hogg@qmul.ac.uk`

For queries outside of lecture time, contact me via email to arrange a meeting.

Module Overview

Aim:
This module aims to introduce you to state-space methods for analysing and designing control systems. You will assess the stability and structural properties of dynamical systems, as well as evaluate their reachability and observability. Finally, you will design feedback controllers systematically to modify the behaviour of the system effectively.

The Focus:
An emphasis is placed on state-space methods for system analysis and controller design.

- with a focus on the stability, controllability, and observability of a system.
- and on the design feedback controllers and state observers.

Course Objectives

Upon successful completion of this module, students will be able to:

- Construct mathematical models of dynamical systems using differential and difference equations.
- Model dynamical systems in the state-space domains.
- Evaluate the stability of dynamical systems.
- Determine controllability and observability in dynamic systems.
- Analyse and predict achievable and non-achievable behaviours in a dynamical system.
- Design feedback controllers systematically to modify the behaviour of dynamical systems.
- Evaluate the impact of different controller designs on system performance and stability.

Module Content

Topics Covered:

- Abstraction of dynamical systems
- Differential and difference equations
- State-space models
- Lyapunov stability
- Input-to-state properties: Reachability and Controllability
- State-to-output properties: Observability and Reconstructability
- State feedback and dynamic output feedback
- Filtering and State Observers

Weekly Plan

Week	Topic	Dates
1	Introduction & State-Space Modelling	22/01 - 28/01
2	Trajectory, Motion and Equilibrium	29/01 - 04/02
3	Linear systems	05/02 - 11/02
4	Lyapunov Stability	12/02 - 18/02
5	Reachability and Controllability (Part 1)	19/02 - 25/02
6	Reachability and Controllability (Part 2)	26/02 - 04/03
7	**Reflection Week** (*No New Material*)	05/03 - 11/03
8	Reconstructability and Observability (Part 1)	12/03 - 18/03
9	Reconstructability and Observability (Part 2)	19/03 - 25/03
10	Feedback	26/03 - 01/04
11	Filtering and State Observers	02/04 - 08/04
12	**Revision Lecture** (*No New Material*)	09/04 - 15/04

Assessment

Final Exam (60%)

- Questions similar to those which will be discussed in the tutorials.

Coursework (40%)

- Two coursework assignments, each worth 20%.
  - QMPlus Quiz (Date: 5/3/2025, worth 20%)
  - Python Coursework (Deadline: 09/04/2025, worth 20%)

Prerequisites

Knowledge Required:

- *Maths, maths and more maths!*
- Linear Algebra
- Ordinary Differential Equations
- Laplace Transform
- Basics of Linear Control Systems

Recommended Textbooks

A Linear Systems Primer *(Essential)*
Authors: Panos J. Antsaklis & Anthony N. Michel
Publisher: Birkhäuser (2007)

Linear state-space control systems *(Essential)*
Authors: Robert L. Williams & Douglas A. Lawrence
Publisher: John Wiley & Sons, Inc. (2007)

Control System Design: An Introduction to State-Space Methods *(Optional)*
Author: Bernard Friedland
Publisher: Dover Publications Inc. (2009)

Additional Resources

Module Notes:
`https://ahogg.github.io/ACS_Notes/ACS_Notes.pdf`

Python Control Systems library
`https://web.math.princeton.edu/~cwrowley/python-control`