Introduction to Automatic Control

Design Exercise

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Contents

High Level Overview

- The coursework task is the **end-to-end** design of a feedback controller for a **real** dynamical system.

- There are three aspects:

  1. System identification
  2. Controller design

     2.1 PID investigation
     2.2 Analytical controller design
     2.3 Analytical controller validation

  3. Experimental controller validation

- Parts 1 and 3 require **experimental work**.

The System

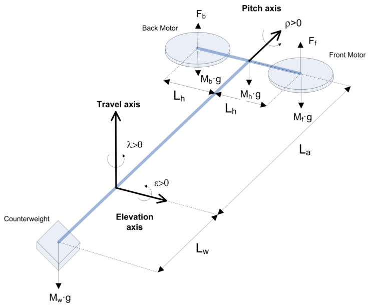
- The aim of the coursework is to design a controller for a Quanser 3DOF Helicopter:

- This hardware is a bench-top representation of a **dual-rotor helicopter**.

- Same hardware has previously been used for many undergraduate and doctoral research projects.

The Problem

- The controller is to be designed to control the elevation axis:



- The learning outcomes that the exercise has been designed to reinforce are your knowledge of
  - Linear time-invariant systems theory
  - SISO controller design techniques

Handout

- All of the information that I will go through is included in the **course handout**.

Introduction to Control
Controller Design Exercise

Dr Sebastian East

Introduction

Please read this **entire document** before starting with any experiments.

The objective of this design exercise is to reinforce the concepts you have learned in lectures by completing the end-to-end design of a controller on real hardware. This will include:

- Identifying a transfer function model from measurements taken from a real system.
- Designing a controller using the theory you have learned in SS&C.
- Validating the controller in both simulation and on hardware.

The experimental parts of the exercise will be conducted on a Quanser 3DOF helicopter, as illustrated in Figure 1 (a). This hardware is a bench-top representation of a tandem-rotor helicopter (such as the Boeing HC-1B Chinook illustrated in Figure 1 (b)), and provides a safe and versatile environment for learning the practical aspects of control system design. Multiple previous undergraduate and PhD research projects have been conducted on these systems.

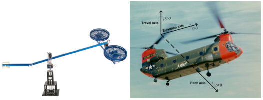


Figure 1: (a) Quanser 3DOF helicopter (b) Boeing HC-1B Chinook

The overall aim of the design exercise is to develop a stabilising controller for the **elevation axis** of the system, as shown in Figure 2.

- This session is an opportunity to emphasise some key points, and for you to ask any questions.

Assessment

- The exercise is **formative**:
  - This means that it is not **directly** assessed
  - This does **not** mean that it is **optional** - the work that you complete in this exercise **may** be built on in the summative assessment

Contents

The Lab

- Equipment can be found Queen's Building M.003
  - Down QB main entrance stairs, left at the bottom, under the cafe

- 4 Quanser Stations

- The lab needs to be accessed **twice**
  - **Data capture (lab)** / controller design / **experimental validation (lab)**
  - Do first **as soon as possible**
  - **Don't** leave second to last minute.

- You **should** do the labs in **pairs**
  - Free to organise your own pairings
  - Don't **have** to work in pairs

Lab Access

- Lab is **unsupervised**.
- Labs can be accessed Monday to Friday 9am to 5pm
  - Labs **are** available over reading week.
- You need to book 1 hour lab sessions in advance.
  - Link in handout and on Blackboard.
- You can use them as often as you need
  - Should only need 1 hour per task
- **Can't guarantee that there will be availability at any given point in term, so organise your time accordingly.**

Operating the Hardware

- Before you can run Matlab on the workstations, you need to put `pathdef.m` into a particular folder.
- When running the hardware you need to
  - Hold the Quanser up to ‘zero’ the encoder when the Simulink file starts
  - Be ready to catch the Quanser when you stop the Simulink file
- You are free to experiment, but please **be careful**
  - The ‘chassis’ is quite fragile.
  - Try not to get your fingers caught in the fans.

Contents

Lab Support

- The **Lab** is run by technical services
  - If something goes wrong, please email `engf-tech-hub@bristol.ac.uk`
  - Include course code in email subject
  - FAO Khalid
  - Include detail in your email
    - The Quanser station
    - Detailed description
    - Copy/paste of any Matlab error message
  - You **won't** be penalised for any accidents

Other Support

- Any other problems please **post on the Teams channel**
  - It is helpful if everyone can see any problems and/or their solutions

Any Questions?