University of BRISTOL

INTRO TO ADVANCED CONTROL

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https://unsplash.com/@cookaynne

Overview

- Course structure and outline
- Overview of Control
- Tools and working practices
- Intro to lab exercise
- Exploration and homework

Learning outcomes

1. formulate and analyse the equations of motion for a rigid body aircraft, and articulate appropriate simplifications for the purposes of classical linear analysis;
2. apply the concepts of aircraft flight balance, flight stability and the standard aircraft modes of motion;
3. evaluate simulated or measured flight data, linking aircraft time histories to flight handling qualities;
4. analyse the stability and robustness properties of negative-feedback control systems;
5. design and characterise control algorithms using classical and modern control techniques;
6. apply control theory to achieve desired aircraft performance and operations.

Where might you end up?

Perspectives on AI

- Personal perspective
- University perspective
  - Institutional (reputation and quality)
  - Learning (utility but cautions)
  - Library
- Assessment perspective
  - UoB
  - Additional thoughts
- Career perspective

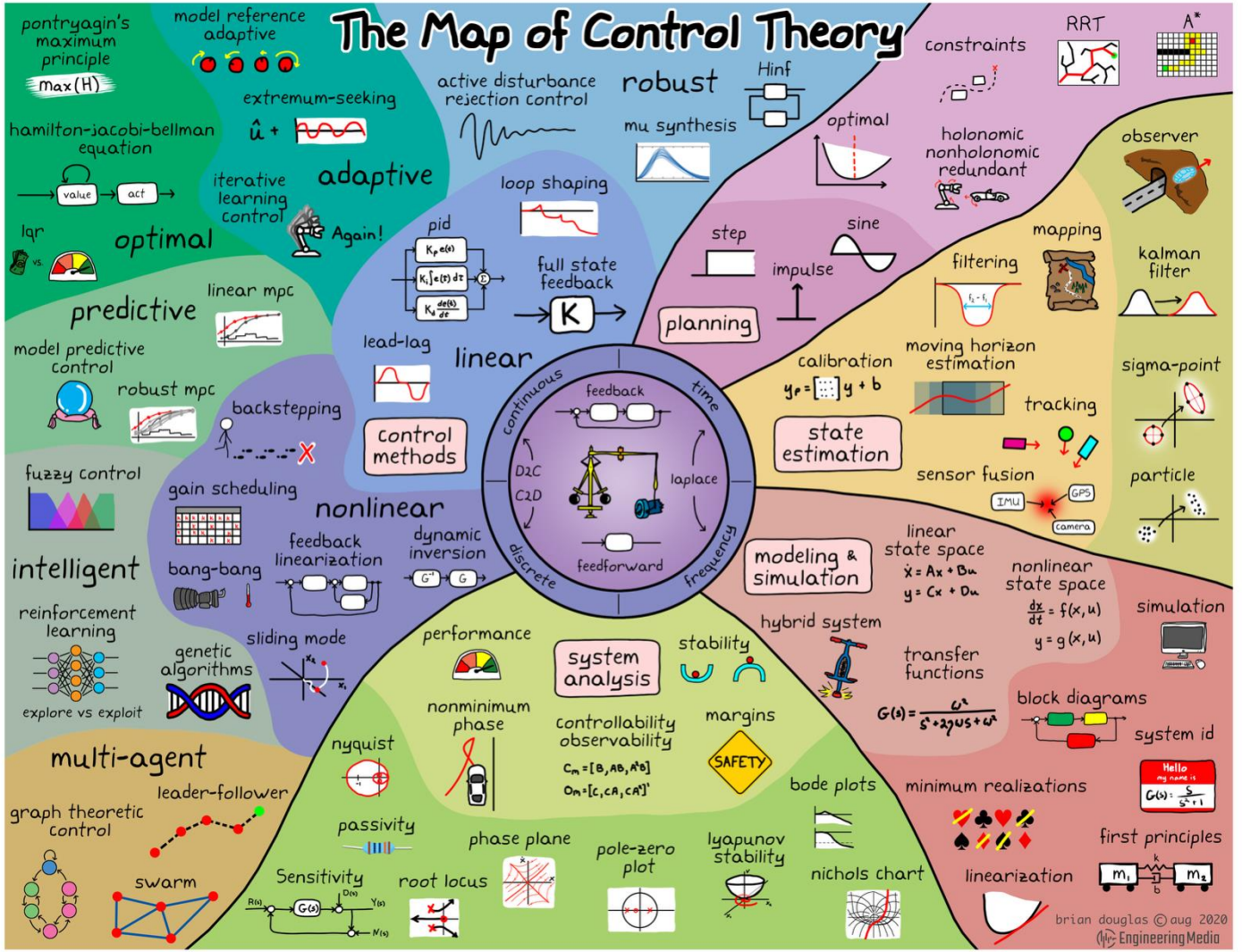
Course goals and format

- Solid grounding in **theory**
  - via lectures and structured independent work
- + Experience in **practice**
  - via guided activities, exploratory workshops, and labs

- = **Confident** in a variety of environments
  - From academia to front-line application
  - With a range of tools, in a range of contexts

Assessment

- 100% coursework
- Released wk5, due wk11
- 50/50 Section A: Flight Dynamics; Section B: Advanced Control
- Front page and assessment rubric on Bb now


The Map of Control Theory
pontryagin's maximum principle
max(H)
model reference adaptive
extremum-seeking
hamilton-jacobi-bellman equation
value
act
iterative learning control
Again!
adaptive
lqr
vs.
optimal
active disturbance rejection control
robust
Hinf
mu synthesis
loop shaping
pid
full state feedback
K
lead-lag
linear
control methods
predictive
linear mpc
model predictive control
robust mpc
backstepping
fuzzy control
gain scheduling
nonlinear
intelligent
bang-bang
feedback linearization
dynamic inversion
reinforcement learning
explore vs exploit
genetic algorithms
sliding mode
multi-agent
leader-follower
graph theoretic control
swarm
continuous
time
discrete
frequency
feedback
feedforward
D2C
C2D
laplace
step
impulse
sine
planning
constraints
RRT
A*
optimal
holonomic
nonholonomic
redundant
observer
mapping
filtering
kalman filter
calibration
moving horizon estimation
sigma-point
tracking
state estimation
sensor fusion
IMU
GPS
camera
particle
modeling & simulation
linear state space
nonlinear state space
simulation
hybrid system
transfer functions
block diagrams
system id
minimum realizations
first principles
linearization
performance
system analysis
stability
nonminimum phase
controllability
observability
margins
SAFETY
nyquist
passivity
phase plane
pole-zero plot
lyapunov stability
bode plots
nichols chart
Sensitivity
root locus
brian douglas © aug 2020
Engineering Media

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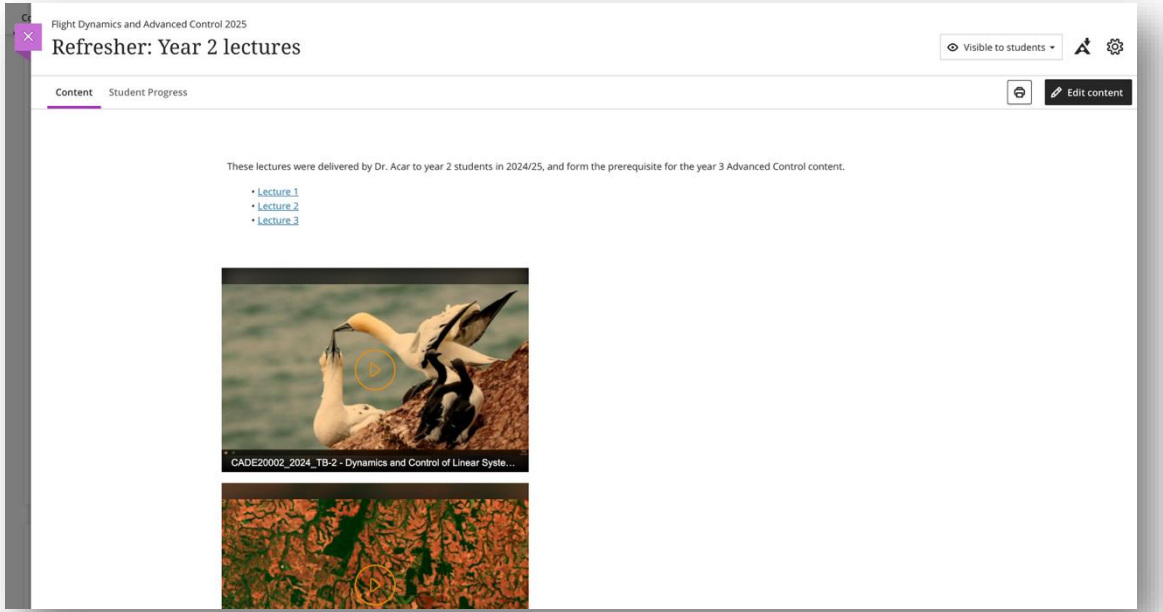
Prerequisites



MATLAB

- Windows/Mac/Linux (iOS/etc via MATLAB Online)
- Local UoB versions upgraded over summer to annual ‘a’ release
  - Although Quanser lab PCs use older versions due to licensing
  - Currently (Oct2025) r2021a
  - Watch out for version incompatibility – backwards 👍, forwards 👎
- MATLAB Online always latest version
  - Not quite as functional or responsive, but improving
  - Need to use desktop app for Quanser activity
- UoB IT Services support

Online resources

- Bb/Unit info/Resource Lists
- Bb/Control/Web links
  - Try Virtual Hardware and Labs

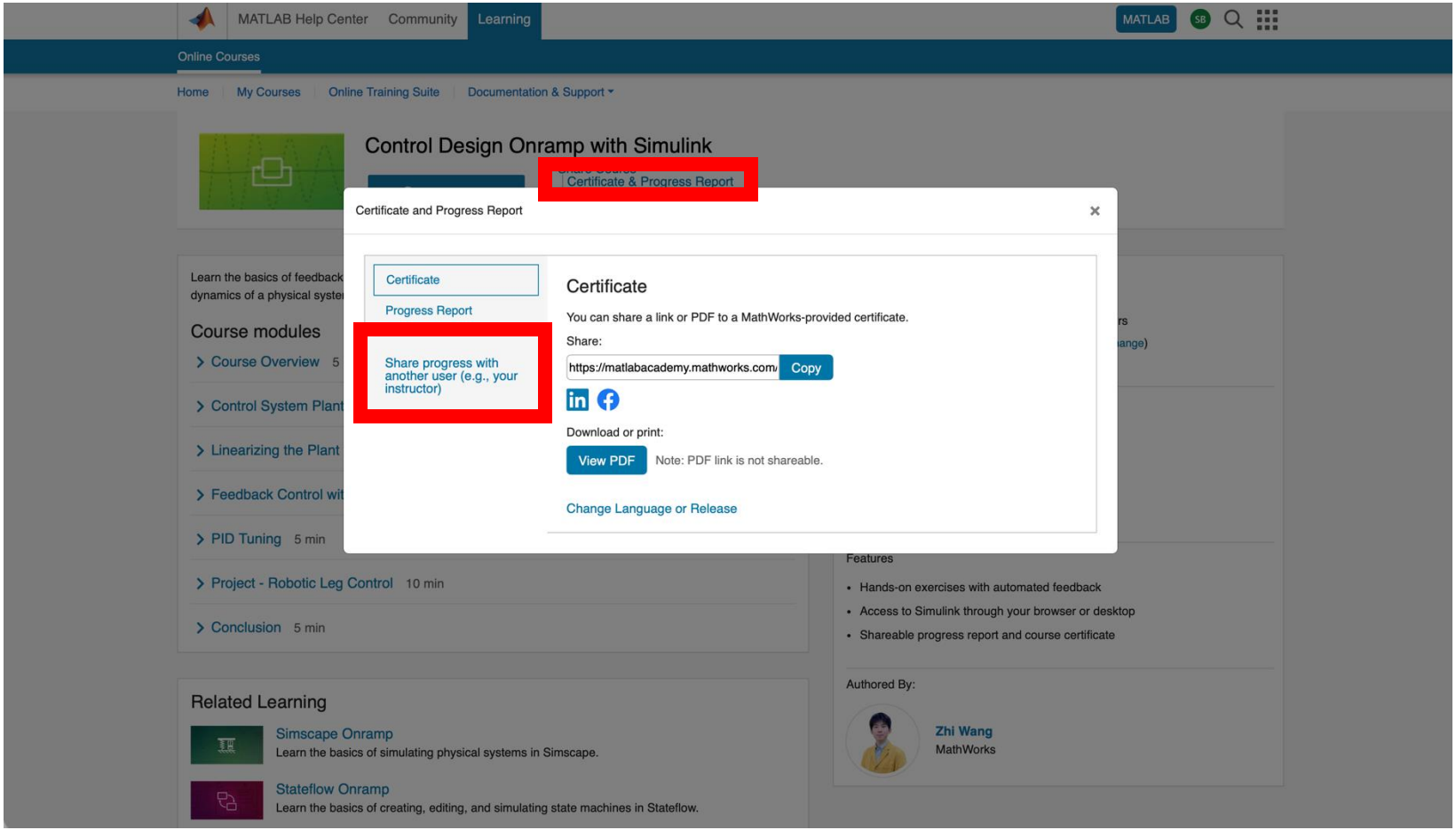
Quanser lab

- Activity 1 – System ID and PID control
- Activity 2 – State Space and LQR

- **Demo!**

Homework

- Complete the MATLAB Academy Control Design Onramp
  - https://matlabacademy.mathworks.com/details/control-design-onramp-with-simulink/controls
- Share your certificate with steve.bullock@bristol.ac.uk
- Deadline: start of next lecture



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Do now - familiarisation

- Download Quanser lab files and dig around
- Try Virtual Hardware and Labs
- Start Control Design Onramp

- X mins independent time, Y mins Q&A

Next week

- Get as confident as you can with MATLAB/Simulink activities
  - Models/virtual labs
  - Real data – Quansers
- Be ready for some deeper theory and maths
  - We'll be emphasising application throughout the course
  - But you'll need to develop and demonstrate links to theory