ACE Network Subject Information Guide

ENGG4400 – Nonlinear Control and Estimation

Semester 2, 2019

Administration and contact details

Host Department	School of Engineering
Host Institution	University of Newcastle
Name of lecturer	Prof. Christopher Kellett
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Subject details

Handbook entry URL	https://www.newcastle.edu.au/course/ENGG4440
Subject homepage URL	https://www.newcastle.edu.au/course/ENGG4440
Honours student hand-out URL	N/A
Start date:	29 July 2019
End date:	8 November 2019
Contact hours per week:	Four (4) hours lecture; Two (2) hours supervised computer laboratory (tutor available via Zoom)
Lecture day and time:	TBA
Description of electronic access arrangements for students (for example, WebCT)	Blackboard

Subject content

1. Subject content description

This course is intended to equip students with an understanding of control and estimation for nonlinear systems. Specifically, the course will cover some basic concepts of nonlinear

systems and control theory such as stability, oscillatory behaviour, Lyapunov theory, differential geometric methods (e.g., feedback linearization), and nonlinear model predictive control. It also covers modern estimation and observer techniques for nonlinear systems.

2. Week-by-week topic overview

Week 1: Lyapunov theory
Week 2: Lyapunov theory
Week 3: Absolute stability
Week 4: Input-to-State Stability, L2-stability, and Small-Gain Analysis
Week 5: Systematic Feedback Design - Control Lyapunov Functions
Week 6: Sliding Mode Control
Week 7: Dealing with Constraints – Linear Matrix Inequalities and Antiwindup Augmentation
Week 8: Introduction to Optimal Control
Week 9: Nonlinear Model Predictive Control or Receding Horizon Optimal Control
Week 10: Introduction to Differential Geometric Concepts, Feedback Linearisation, and Output Regulation
Week 11: Introduction to Nonlinear Observers – Luenberger and Sliding Mode Observers
Week 12: Nonlinear Kalman Filtering and High-Gain Observers
Week 13: Observers for Systems with Symmetry

3. Assumed prerequisite knowledge and capabilities

Linear algebra, calculus, differential equations at a level usually taught in first/second year mathematics.

4. Learning outcomes and objectives

- Understand the common tools used to analyse the behaviour of a nonlinear system
- Apply tools from Lyapunov theory to commonly encountered nonlinear systems
- Design and implement feedback control systems for regulating the output of a nonlinear system
- Design and implement antiwindup systems to improve nonlinear system performance
- Model uncertainty in engineering systems
- Formulate decision problems in the presence of uncertainty
- Design and implement observers and estimators for nonlinear systems

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below

Learning Outcome Descriptors at AQF Level 8

Knowledge

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

Skills

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

Application of Knowledge and Skills

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

5. Learning resources

Primary Text

1. C. M. Kellett, *Nonlinear Control and Estimation*, Electronic Notes (PDF), 2019.

Required software

MATLAB

Supplementary Texts

1. K.J. Astrom and R.M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, 2009.
2. J.P. Hespanha, *Linear Systems Theory*, Princeton University Press, 2009.
3. H.K. Khalil, *Nonlinear Systems* (3rd Edition), Prentice Hall, 2001.

6. Assessment

Lab exercise/assignment breakdown					
Lab Exercises (7)	10 % Each	**Assignments (2)**	15 % Each		
Lab Exercise due dates	Weeks 3, 4, 7, 8, 9, 10, 13				
Assignment due dates	Weeks 9, 13				
Approximate exam date				N/A	

Institution Honours program details

Weight of subject in total honours assessment at host department	10 of 80 units (12.5%)
Thesis/subject split at host department	30 of 80 units (37.5%)
Honours grade ranges at host department:	
H1	85 or above %
H2a	75 to 84 %
H2b	65 to 74 %
H3	50 to 64 %