SUBJECT OUTLINE

41014 Sensors and Control for Mechatronic Systems

Course area	UTS: Engineering
Delivery	Spring 2020; standard mode; City
Subject classification	Fields of practice: Mechanical and Mechatronic Engineering major
Credit points	6cp
Requisite(s)	48623 Mechatronics 2 AND 48660 Dynamics and Control
Result type	Grade and marks

Attendance: Forms of attendance and mode of delivery in this subject have changed to enable social distancing and reduce the risks of spreading COVID-19 in our community.
Recommended studies: basic knowledge of classical control techniques

Subject coordinator

Dr. Liang Zhao

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Teaching staff

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General enquiries, Sensing, Control, Quiz, Projects, Final Exam

Consultation in FLP: 2pm - 3pm Tuesday, 1pm - 2pm Friday.

Mr. Maleen Jayasuriya (Tutor)

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Tutorial and hands-on activities

Subject description

The objectives of this subject are to develop the student's theoretical and practical understanding on active and passive sensing and feedback control techniques in mechatronic and robotic systems, ability to select and evaluate sensors, process the sensor data, and apply computer-based tools for practical control system design using the sensory information. Topics include visual imaging and image processing, infrared imaging, time of flight (TOF) measurements, detection and tracking, state-space modelling of linear systems, stability, controllability and observability, linear quadratic control, observer design, H-infinity control, and model predictive control. Case studies of engineering applications are used to illustrate and examine these concepts.

Subject learning objectives (SLOs)

Upon successful completion of this subject students should be able to:

1. Implement sensors and processing techniques and control strategies.

2. Apply knowledge of image processing and active sensor processing
3. Apply knowledge of advanced control techniques.
4. Design sensors, signal processing and control solutions to practical problems

Course intended learning outcomes (CILOs)

This subject also contributes specifically to the development of the following Course Intended Learning Outcomes (CILOs):

- Design Oriented: FEIT graduates apply problem solving, design and decision-making methodologies to develop components, systems and processes to meet specified requirements. (C.1)
- Technically Proficient: FEIT graduates apply abstraction, mathematics and discipline fundamentals, software, tools and techniques to evaluate, implement and operate systems. (D.1)
- Collaborative and Communicative: FEIT graduates work as an effective member or leader of diverse teams, communicating effectively and operating within cross-disciplinary and cross-cultural contexts in the workplace. (E.1)

Teaching and learning strategies

The teaching and learning strategies focus on:

- Online preparatory materials for in-class activities
- Practical tutorial problems for students to apply the learned techniques
- Practical project problems for students to design an integrated system using the sensors and control techniques
- Collaborative group work and active hands on work

Content (topics)

- Passive Sensors: Visual imaging and image processing, Infrared imaging
- Basics of Active Sensors: Operating principles, time of flight (TOF) measurement & imaging, sensor data processing, Detection and tacking
- State space modelling of dynamic systems: linear continuous time model, linear discrete time model,
- Fundamental issues in control system design: Lyapunov stability, controllability, observability, stabilization, pole assignment.
- Linear optimal control: linear quadratic control, observer design
- H-infinity control
- Model predictive control

Program

Week/Session	Dates	Description
1	27 July	Week1 Activities Log on to UTSOnline and go through the material given in Week 1. This provides an introduction to the Image processing toolbox and a general introduction to Matlab software. Knowledge of Image processing toolbox and Matlab language is necessary for this subject. Therefore, it is highly recommended for you to go through the materials before the class. Active hands on: Introduction to Sensors and Control for Mechatronic Systems
2	3 August	Make sure you are familiar with the Week 2 materials. Knowledge of them are essential for the inclass activities. Active hands on: Image Processing I

3	10 August	Log on to UTSOnline and go through the material given in Week 3. We assume your knowledge of online materials for class activities. Active hands on: Image Processing II **Notes:** **Assessment Task 1: Quiz 1** (Written feedback will be provided when marking)
4	17 August	Log on to UTSOnline and go through the material given in Week 4. We assume your knowledge of online materials for class activities. Active hands on: Image Processing III
5	24 August	Log on to UTSOnline and go through the material given in Week 5. We assume your knowledge of online materials for class activities. Active hands on: TOF sensors
6	31 August	Log on to UTSOnline and go through the material given in Week 6. We assume your knowledge of online materials for class activities. Active hands on: Detection and Tracking
7	7 September	Log on to UTSOnline and go through the material given in Week 7. We assume your knowledge of online materials for class activities. Active hands on: Control I
S1	14 September	**Mid-Session StuVac**
8	21 September	Log on to UTSOnline and go through the material given in Week 8. We assume your knowledge of online materials for class activities. Active hands on: Control II
9	28 September	Log on to UTSOnline and go through the material given in Week 9. We assume your knowledge of online materials for class activities. Active hands on: Control III **Notes:** **Assessment Task 2: Quiz 2** (Written feedback will be provided when marking)

10	5 October	Log on to UTSOnline and go through the material given in Week 10. We assume your knowledge of online materials for class activities. Active hands on: Integrating image processing and control I
11	12 October	Subject review and group project help. **Notes:** Work on the projects.
12	19 October	Group project presentation, demo, and report (Oral feedback is provided during demonstration) **Notes:** **Assessment Task 3: Project** due 2020-10-20 at 18:00
S2	26 October	**Final StuVac**
A1-A2	2 November - 13 November	**Assessment Task 4: Exam**

Assessment

Assessment task 1: Quiz 1

Intent: The aim of this quiz is to assess the competence in image processing techniques.

Objective(s): This assessment task addresses the following subject learning objectives (SLOs):

1 and 2

This assessment task contributes to the development of the following Course Intended Learning Outcomes (CILOs):

C.1

Type: Quiz/test

Groupwork: Individual

Weight: 5%

Task: This quiz will assess students' understanding of sensors and data processing techniques involved in mechatronic systems. Students will need to understand the sensors' principle, applications and hands-on activities of sensors' data processing.

Due: In Class Week 3 (2020-08-10)

Assessment task 2: Quiz 2

Intent: The aim of this quiz is to assess the competence in sensors, sensor processing and control techniques.

Objective(s): This assessment task addresses the following subject learning objectives (SLOs):

1, 3 and 4

This assessment task contributes to the development of the following Course Intended Learning Outcomes (CILOs):

C.1

Type: Quiz/test

Groupwork: Individual

Weight: 15%

Task: The quiz will assess students' understanding of the control methods used in mechatronic systems. Students will need to understand the definition, formulation, analysis and optimal control methodology of different control systems. This quiz will provide examples of questions students will face in the final exam.

Due: In Class Week 9 (2020-09-28)

Assessment task 3: Project

Intent: For students to apply sensing and control strategies to achieve an integrated solution to given specifications in a robotics system specifications.

Objective(s): This assessment task addresses the following subject learning objectives (SLOs):

1, 2 and 4

This assessment task contributes to the development of the following Course Intended Learning Outcomes (CILOs):

C.1 and E.1

Type: Project

Groupwork: Group, group and individually assessed

Weight: 50%

Task: For this group task, at least 20% is individually marked. Each group of students will need to complete the implementation of a sensing and control algorithm for the group project they are allocated and demonstrate to the supervisor the effectiveness of the algorithm in fulfilling the project requirements.

Each group will write a report detailing the project requirements, the methodology adopted, the algorithms implemented and the final results achieved. See the project document on UTSOnline for more details.

Example projects:

- Fetch robot following a path
- Fetch robot grasping
- Control and grasping for the DoBot Robot

- Hand-eye calibration for the DoBot Robot
- 3D reconstruction using RGB-D camera and EM sensor
- Robot following a straight line by observing a square using Turtlebot
- Turtlebot robots following each other
- Autonomous unloading dock - Pick up building block from Turtlebot with UR3 Arm using Visual Servoing

Due: 20 October 2020 at 18:00

Assessment task 4: Timed Take Home Exam

Intent: The aim of the final exam is to assess students' deeper knowledge gained through lectures, lab classes and projects.

Objective(s): This assessment task addresses the following subject learning objectives (SLOs):

1, 2, 3 and 4

This assessment task contributes to the development of the following Course Intended Learning Outcomes (CILOs):

C.1 and D.1

Type: Examination

Groupwork: Individual

Weight: 30%

Task: Open book exam

This is an open book exam which will assess students' understanding of sensors and processing techniques, and control strategies for mechatronic systems e.g. camera calibration, laser scanner linear and nonlinear discrete-time control system.

Due: UTS Exam period

Further information: The exam is an open book exam. Materials such as lecture notes are allowed into the exam.

Programmable calculators may be used.

Assessment feedback

Feedback will be given to each assessment via face to face discussions and using UTSOnline discussion boards before the end of the session.

Minimum requirements

In order to pass the subject, a student must achieve an overall mark of 50% or more.

References

[1] Nixon, Mark S, Feature extraction & image processing for computer vision, Oxford : Academic, 2012

[2] Introduction to Sensors for Ranging and Imaging by Graham Brooker, Sci Tech Publishing Inc., 2009

[3] Image Processing Toolbox, https://au.mathworks.com/products/image.html

[4] Image Acquisition Toolbox, https://au.mathworks.com/products/imaq.html

[5] Camera Calibration Toolbox, http://www.vision.caltech.edu/bouguetj/calib_doc/

[6] Katsuhiko Ogata, Modern Control Engineering, (3rd Edition)

[7] Jefferey B. Burl, Linear Optimal Control, Addison Wesley.

[8] Control Tutorial for MATLAB, http://www.engin.umich.edu/group/ctm/state/state.html

[9] J.M. Maclejowski, Multivariable Feedback Design, Addison-Wesley, 1989

[10] Branislav Kisacanin, Gyan C. Agarwal, Linear Control Systems: With Solved Problems and MATLAB Examples

[11] Control system toolbox, http://www.mathworks.com/products/control/

[12] Katsuhiko Ogata, Discrete-Time Control Systems (2nd Edition)

Graduate attribute development

For a full list of the faculty's graduate attributes refer to the FEIT Graduate Attributes webpage.

For the contribution of subjects taken in the Bachelor of Engineering (Honours) or Master of Professional Engineering to the Engineers Australia Stage 1 Competencies, see the faculty's Graduate Attributes and the Engineers Australia Stage 1 Competencies webpage.

Assessment: faculty procedures and advice

Marking criteria

Marking criteria for each assessment task is available on the Learning Management System: UTS Online.

Extensions

When, due to extenuating circumstances, you are unable to submit or present an assessment task on time, please contact your subject coordinator before the assessment task is due to discuss an extension. Extensions may be granted up to a maximum of 5 days (120 hours). In all cases you should have extensions confirmed in writing.

Special consideration

If you believe your performance in an assessment item or exam has been adversely affected by circumstances beyond your control, such as a serious illness, loss or bereavement, hardship, trauma, or exceptional employment demands, you may be eligible to apply for Special Consideration.

Late penalty

Work submitted late without an approved extension is subject to a late penalty of 10 per cent of the total available marks deducted per calendar day that the assessment is overdue (e.g. if an assignment is out of 40 marks, and is submitted (up to) 24 hours after the deadline without an extension, the student will have four marks deducted from their awarded mark). Work submitted after five calendar days is not accepted and a mark of zero is awarded.

For some assessment tasks a late penalty may not be appropriate – these are clearly indicated in the subject outline. Such assessments receive a mark of zero if not completed by/on the specified date. Examples include:

a. weekly online tests or laboratory work worth a small proportion of the subject mark, or
b. online quizzes where answers are released to students on completion, or
c. professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
d. take-home papers that are assessed during a defined time period, or
e. pass/fail assessment tasks.

Querying results

If you believe an error may have been made in the calculation of your result in an assessment task or the final result for the subject, it is possible to query the result with the Subject Coordinator within five (5) working days of the date of release of the result.

Academic liaison officer

Academic liaison officers (ALOs) are academic staff in each faculty who assist students experiencing difficulties in their studies due to: disability and/or an ongoing health condition; carer responsibilities (e.g. being a primary carer for small children or a family member with a disability); and pregnancy.

ALOs are responsible for approving adjustments to assessment arrangements for students in these categories. Students who require adjustments due to disability and/or an ongoing health condition are requested to discuss their situation with an accessibility consultant at the Accessibility Service before speaking to the relevant ALO.

Statement about assessment procedures and advice

This subject outline must be read in conjunction with the Coursework Assessments policy and procedures.

Statement on copyright

Teaching materials and resources provided to you at UTS are protected by copyright. You are not permitted to re-use these for commercial purposes (including in kind benefit or gain) without permission of the copyright owner. Improper or illegal use of teaching materials may lead to prosecution for copyright infringement.

Statement on plagiarism

Plagiarism and academic integrity

At UTS, plagiarism is defined in Rule 16.2.1(4) as: 'taking and using someone else's ideas or manner of expressing them and passing them off as ... [their] own by failing to give appropriate acknowledgement of the source to seek to gain an advantage by unfair means'.

The definition infers that if a source is appropriately referenced, the student's work will meet the required academic standard. Plagiarism is a literary or an intellectual theft and is unacceptable both academically and professionally. It can take a number of forms including but not limited to:

- copying any section of text, no matter how brief, from a book, journal, article or other written source without duly acknowledging the source
- copying any map, diagram, table or figure without duly acknowledging the source
- paraphrasing or otherwise using the ideas of another author without duly acknowledging the source
- re-using sections of verbatim text without using quote marks to indicate the text was copied from the source (even if a reference is given).

Other breaches of academic integrity that constitute cheating include but are not limited to:

- submitting work that is not a student's own, copying from another student, recycling another student's work, recycling previously submitted work, and working with another student in the same cohort in a manner that exceeds the boundaries of legitimate cooperation
- purchasing an assignment from a website and submitting it as original work
- requesting or paying someone else to write original work, such as an assignment, essay or computer program, and submitting it as original work.

Students who condone plagiarism and other breaches of academic integrity by allowing their work to be copied are also subject to student misconduct Rules.

Where proven, plagiarism and other breaches of misconduct are penalised in accordance with UTS Student Rules Section 16 – Student misconduct and appeals.

Avoiding plagiarism is one of the main reasons why the Faculty of Engineering and IT is insistent on the thorough and appropriate referencing of all written work. Students may seek assistance regarding appropriate referencing through UTS: HELPS.

Work submitted electronically may be subject to similarity detection software. Student work must be submitted in a format able to be assessed by the software (e.g. doc, pdf (text files), rtf, html).

Further information about avoiding plagiarism at UTS is available.

Retention of student work

The University reserves the right to retain the original or one copy of any work executed and/or submitted by a student as part of the course including, but not limited to, drawings, models, designs, plans and specifications, essays, programs, reports and theses, for any of the purposes designated in Student Rule 3.9.2. Such retention is not to affect any copyright or other intellectual property right that may exist in the student's work. Copies of student work may be retained for a period of up to five years for course accreditation purposes. Students are advised to contact their subject coordinator if they do not consent to the University retaining a copy of their work.

Statement on UTS email account

Email from the University to a student will only be sent to the student's UTS email address. Email sent from a student to the University must be sent from the student's UTS email address. University staff will not respond to email from any other email accounts for currently enrolled students.