Mechanical and Manufacturing Engineering

Course Outline

Semester 1 2018

MTRN4110

ROBOT DESIGN

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr. Jose Guivant
Office: Room 510D, Building J17
Tel: (02) 9385 5693
Email: j.guivant@unsw.edu.au

The consultation time slots will be announced later.

Consultations are possible outside the set times, but a prior appointment would be preferred. Email and Moodle discussions can also be used for solving more general issues.

Contact details and consultation times for additional lecturers/demonstrators/lab staff

Name: Dr. Ngai M. Kwok
Office: Room 510C, Building J17
Tel: (02) 9385 6091
Email: nmkwok@unsw.edu.au

Consultation with Dr Kwok concerning this course will by appointment. Direct consultation is preferred; email may also be used.

Please see the course Moodle.

2. Important links

- Moodle
- UNSW Mechanical and Manufacturing Engineering
- Course Outlines
- Student intranet
- UNSW Mechanical and Manufacturing Engineering Facebook
- UNSW Handbook

3. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, which involves four (4) hours per week (h/w) of face-to-face contact.

The UNSW website states "The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week."

This means that you should aim to spend about 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	Time	Location
Lectures	Monday	14:30 – 16:00	Old Main Building 149 (K15-149)
Lab/projects	Please check your timetable	Please check your timetable	J18 / Mechatronics Lab.

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

Summary and Aims of the course

This course focuses on the design and implementation of the perception and control capabilities of an autonomous robotic platform. When we say design and implementation of an autonomous platform, we are implicitly talking about the hardware (mechanical and electronic components) and the software (low and high-level modules) for the tasks of perception and control. This year, 2018, we will focus on the software components of the robot, the sensors (RGB, 3D and inertial) for providing perception capabilities to the hexapods which are used in the projects. The perception will allow the platform to localize itself (estimate its position), maintain a map of the context of operation, and perform path planning based on that map.

Half of the course is lecture-based; in the other half, the students apply the concepts on real data and a real platform (Hexapod).

Based on your work in this course, it is expected that you will be able to:

- Improve skills in programming (Matlab).
- Improve skills in applying mathematics and programming concepts for solving problems related to perception and control.
- Acquire experience working with a diversity of sensors including concepts about processing sensors' measurements and other concepts needed for implementing the robot's perception and control capabilities.
- Understand the multiple components of an intelligent robotic system.
- Understand and apply specific concepts such as localization, mapping and certain advanced control techniques, which can be used in diverse areas of application.

Concepts included in this course are useful for other disciplines, in research and industrial application.

Student learning outcomes

This course is designed to address the following learning outcomes and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers, as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

After successfully completing this course, students should be able to:

Learning Outcome		**EA Stage 1 Competencies**
1.	Understanding of the general theory of Dynamic Programming (and specifically the Dijkstra's algorithm) for non-linear control problems	PE1.1
2.	Understanding 3D attitude definition and its estimation, triangulation, and other localization approaches.	PE1.1
3.	Understand diverse concepts on Image processing: contrast enhancement, noise reduction, scaling /interpolation, edge/corner/line detection, wavelet processing, shape descriptors. Computer vision techniques for feature/object detection and extraction.	PE1.1
4.	Be able to develop software for applying the theory and solving complex problems. Get experience in using state of the art sensors used in robotics and autonomous systems (digital servos, RGB cameras, Depth cameras, inertial systems)	PE2.3

4. Teaching strategies

Teaching of this course is implemented through lectures to cover the theory, and project sessions to put those concepts in practice. All laboratory/project work is individual work, and attendance is necessary.

The provision of the learning environment in the laboratory is to facilitate the students to develop confidence in managing laboratory tasks as projects. Demonstrators in the laboratories are there to provide guidance and assistance in managing the laboratory tasks.

Examples (e.g. source code) for the projects are provided by the Lecturer, to help in the understanding and full implementation of the projects. Project complexity is incremental, to allow the student to finally complete the solution of a complex problem.

5. Course schedule

Topic	Date	Loc.	Lecture Content	Suggested Readings
Introduction / sensors used in MTRN4110	week 1	LR	Introduction: about the course and the platforms used in the projects (Hexapods). Sensors used in 4110: Inertial measurement unit (IMU), RGB-D (RGB+3D) cameras, etc. Real-time explanation and demos in class.	Moodle lecture notes
3D attitude Estimation.	week 2	LR	3D attitude. 3D rotations. 3D coordinate frames. Integrating gyroscopes for estimating 3D attitude. Calibrating IMU's gyros. Implementing related processing in a computer. Examples and real-time demos in class.	Moodle lecture notes
2D and 3D perception	week 3,4	LR	Raw 3D data from sensors: RGB-D cameras. Using depth information in our projects. Processing data: Detecting usual 3D indoor flat surfaces (floor, walls). Detecting 2D features. Exploiting well-known Mathematics: Least squares. Singular Value Decomposition (SVD). Feature Extraction from 2D and 3D imagery. Tracking OOIs (Objects of Interest). Data association. Hough Transform in 2D	Moodle lecture notes
Localization and modelling context	Week 5	LR	2D (3DoF) Localization of the platform. Triangulation using a map. 3D attitude estimation based on accelerometers and 3D imagery. Terrain modelling from 2D and 3D perception. Discrete representation. Occupancy Grids.	Moodle lecture notes
Image processing 1	Week 6	LR	Contrast enhancement, noise reduction, scaling/interpolation	Moodle lecture notes
Image processing 2	Week 7	LR	Edge/corner/line detection, wavelet processing, shape descriptor	Moodle lecture notes
Computer vision 1	Week 8	LR	Feature/object detection and extraction	Moodle lecture notes
Computer vision 2	week 9	LR	Object tracking/estimation, multi-view geometry	Moodle lecture notes

Topic	Date	Loc.	Lecture Content	Suggested Readings
Control and Planning	week 10	LR	Optimal control / path planners: Dynamic Programming (Bellman Principle of Optimality). Dijkstra's approach,	Moodle lecture notes
Robots under limited resources.	week 11	LR	Robot resources: Energy and power concepts. Storage: Batteries, super capacitors. Communications resources. Sharing data among nodes/robots. Data rates/ bandwidth, latencies. Estimating necessary bandwidth.	Moodle lecture notes
Kinematic of Legged robots Servos	week 12	LR	Forward and inverse kinematics. General definition. Particular case: hexapods. Usual actuators: servos.	Moodle lecture notes
Contingency time. Revision	week 13	LR		

Note: LR = lecture Room = Old Main Building 149 (K15-149)

6. Assessment

Assessment Overview

Assessment task	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Projects	4 projects	50%	1,2,3,4	Refer to assignment specifications for exact details.	See details in the section about Projects	See details in the section about Projects	See details in the section about Projects
Final exam	2 hours	50%	1,2,3,4	All course content from weeks 1-12	Exam period, date TBC.	N/A	Upon release of final results

Necessary conditions, in order to pass the course:

a) The exam mark must be 50/100 or higher.
b) The total mark of the project component must be 50/100 or higher.

Projects

Assessment task	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Project 1	Completely operational software	*12%*	2,4	Refer to assignment specification for exact details (note 1).	Meeting with a demonstrator, week 4.	1 week later	< 10 days later
Project 2	Completely operational software	*20%*	2,4	Refer to assignment specification for exact details (note 1).	Meeting with a demonstrator, week 7.	1 week later	< 10 days later
Project 3	Completely operational software	*30%*	3,4	Refer to assignment specification for exact details (note 1)	Meeting with a demonstrator, week 10.	1 week later	< 10 days later
Project 4	Completely operational software	*38%*	1,2,3,4	Refer to assignment specification for exact details (note 1).	Meeting with a demonstrator, week 13.	Monday, “week 14”	< 10 days later

Note 1: Provided via Moodle; 1 week before the official release of the project.

Task demonstrations may be preceded by a short quiz, whose result would be part of the marking scheme for the task. For each task, students will be informed in advance if the demonstration of the task will include a quiz. The relevance of the quiz on the final mark of the task will be informed in advance to students. The topic of the quiz will be related to the task being evaluated, on matters which the student should know for solving that task.

Assignments

Each of the four tasks (which contribute to the final mark) will be presented/demonstrated by the student, individually. All of your programs and results must be explained to your demonstrator. A significant portion of the marks are the result of your demonstration of knowledge about the task during your meeting with the demonstrator.

A short quiz (for all the students in a lab session) before the demonstration may be required by the demonstrators. In such cases, the quiz would commence 10 minutes past the nominal starting time of the lab/project session. Students who are not able to attend a demonstration session must apply for special consideration.

At the end of each demonstration, you must submit your software and report (if required) in a zipped file via a Moodle submission site. The deadline for that submission will be known before the demonstration. Details about the format and name convention for program files and reports will be specified with the release of the tasks and projects.

Submission

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Special consideration for assessment tasks must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Where there is no special consideration granted, the 'deadline for absolute fail' in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

Marking

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Examinations

The exam's duration is two (2) hours. It involves substantial part of the theory (presented in the lectures) and questions about the projects/tasks which were solved by the students during the session.

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2.

For further information on exams, please see the Exams section on the intranet.

Calculators

You will need to provide your own calculator, of a make and model approved by UNSW, for the examinations. The list of approved calculators is shown at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an "Approved" sticker for it from the School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

Special consideration and supplementary assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see the School intranet, and the information on UNSW's Special Consideration page.

7. Attendance

You are required to attend a minimum of 80% of all classes, including lectures, labs and seminars. It is possible to fail the course if your total absences equal to more than 20% of the required attendance. Please see the School intranet and the UNSW attendance page for more information.

8. Expected resources for students

All the academic material is provided by the lecturers (lecture notes, example data, software libraries, example code, sensors and equipment).

In addition to the real-time data provided by the sensors, datasets of typical measurements are provided for allowing the students to perform playback sessions and work at home when needed.

Lecture notes and projects specifications will be available on Moodle in advance before the class.

Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Other Resources

Although the material taught in the course is fully covered by the provided lecture notes, some deviations are inevitable. If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library.

UNSW Library website: https://www.library.unsw.edu.au/

9. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, recent improvements resulting from student feedback include:

- Extended opening time to laboratories and computers.
- Demonstrators: better coverage of laboratory hours.
- Clear specification for projects / individual projects.

10. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism: student.unsw.edu.au/plagiarism The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:
www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

11. Administrative matters and links

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

Jose Guivant
1st February 2018

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership