UNSW AUSTRALIA

Course Outline

Semester 1 2016

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MTRN4110

ROBOT DESIGN

Contents

1. Staff Contact Details

Contact details and consultation times for course convenor

Name: Dr Jose Guivant
Office: ME311B, J17
Tel: (02) 9385 4096
Email: J.Guivant@unsw.edu.au

Consultation Times: To be agreed with students, before week 2.

2. Course details

Credit Points:

This is a 6 unit-of-credit (UoC) course, and involves 5 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

Lecture	Day	Time	Location
	Wednesday	09:00 – 11:00	Civil Eng. 101(H20)
Projects/ Lab	Wednesday	12:00 – 15:00	Mechatronic Lab 212 (J18)
	Wednesday	15:00 – 18:00	Mechatronic Lab 212 (J18)
	Thursday	09:00 – 12:00	Mechatronic Lab 212 (J18)
	Friday	09:00 – 12:00	Mechatronic Lab 212 (J18)
	Friday	12:00 – 15:00	Mechatronic Lab 212 (J18)

(Note: Projects/Lab sessions take place during weeks 2-13; lectures during weeks 1-13)

Summary 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 (a robotic vehicle) 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, 2016, we will focus on the Software components of the robot, the sensors and actuators, in particular for the Perception and

Control components of the hexapods used in the projects. We will need to solve the actuation part which involves controlling, simultaneously, 18 servos of each hexapod platform; considering the kinematic of the platform and the physical limitations of the servos (acceleration, speed, torque and the dynamic end of run constraints). The perception of the platforms will be based on 3D cameras and 3D inertial systems.

Half of the course is lecture-based. In the other half, the students apply the concepts on real data and a real platform (UGV -Unmanned Ground Vehicle).

Aims of the Course

At the conclusion of this course, it is expected that you will be able to:

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

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

Student learning outcomes

This course is designed to address the below 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, you 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 Comprehensive, theory-based understanding of underpinning fundamentals
2.	Understanding the Kinematic models of wheeled and a legged platforms. Understanding of 3D Attitude definition and estimation; triangulation and other localization approaches.	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
3.	Be able to develop software for applying the theory and actually solving complex problems. Get experience in using state of the art sensors and actuators, used in Robotics and Autonomous Systems (digital servos, RGB cameras, Depth cameras, inertial systems and diverse lower cost sensors)	PE2.3 Application of systematic engineering synthesis and design processes

3. Teaching strategies

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

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

Example source code for the projects is provided, in order to help in the understanding and full implementation of the projects.

Complexity of the projects is incremental, in order to allow the student to finally complete the solution of a complex problem.

Access to real sensors and platforms is an additional feature to gain experience for future industrial and research activities.

4. Course schedule

Topic	**Date**	**Location**	**Lecture Content**	**Suggested Readings**
Introduction / sensors	Week 1	LR	Course Introduction Robot's low level Perception: Sensing. Description of sensors used in MTRN4110's platforms: 3D accelerometers, 3D Gyroscopes, wheel and steering encoders, 3D cameras, servos (control and feedback). Demonstrations and Examples in Matlab / Python, for processing measurements and performing visualization	Provided examples, Moodle
	Week 2		Continuation previous topic (1 hour). Start topic for week 3 (1 hour)	
Localization	Week 3	LR	Localization of the platform based on "dead-reckoning". Cases of fusion of wheel encoders + steering encoders + gyroscopes. Kinematic models of the platforms, Demonstration and examples applied on real platforms.	Moodle lecture notes
Kinematic of Legged platforms	Week 4		Kinematic of a simple leg. Kinematic of a multi-legged platform (hexapod case). Using servos as actuators.	Moodle lecture notes

3D attitude	Week 5	LR	Definition of 2D and 3D attitude. Conventions. Estimation of attitude in 3D. Processing Gyroscopes' measurements for estimating 2D and 3D attitude. Using accelerometers for estimating Roll and Pitch. Alternative approaches. Bias estimation and removal, for angular velocities.	Moodle lecture notes
Localization in 2D. Triangulation.	Week 6	LR	Localization based on Navigation Maps, using 3D camera. Feature Extraction. Data Association. Triangulation (Range Only, Bearing Only and Range and Bearing) How does a GPS work?	Moodle lecture notes
Dense Mapping Terrain Modelling	Week 7	LR	Mapping. Occupancy Grids for describing the context of operation. Processing 3D images for terrain modelling. Inferring obstacles. Code: Examples and Demonstrations.	Moodle lecture notes
Revision	Week 8	LR	Reviewing all previous lectures. Discussion: Concurrent operation of the multiple perception processes.	Discussion in class. Demonstration by the lecturer
Hough Transform	Week 9	LR	Hough Transform. Applying HT to images provided by laser scanners and 3D camera, for estimating surfaces.	Moodle lecture notes
Planning 1	Week 10	LR	Control of the robotic platform: Advanced Control: Dynamic Programming. Bellman's Principle of Optimality. Dijkstra's method. Path Planning: Dijkstra's method applied to 2D path planning. Using grid maps for planning. Examples and Demonstration of a Dijkstra's planner.	Moodle lecture notes
Planning 2	Week 11	LR	Alternative approaches. Variations of the Dijkstra's method	Moodle lecture notes
System Integration	week 12	LR	Integrating the full system. (Perception and Control)	Moodle lecture notes
Revision	week 13	LR	Revision	N/A

(note: LR = lecture Room = Civil Eng. 101 (H20))

5. Assessment

Assessment task	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements
Projects	4 projects	50%	1,2,3	Refer to assignments specifications for exact details.	See details in the section about Projects
Final exam	2 hours	50%	1,2	All course content from weeks 1-12	Exam period, date TBC

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	Weight (of Project component)	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements
Task 0	0%	(refreshing concepts and skills)	--	No assessment.
Task 1	9%	2,3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 4. (2)
Task 2	9%	2,3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 6. (2)
Project 1	40%	1,2,3	Refer to assignment specification for exact details (*)	Meeting with a demonstrator during week 9. (2)
Project 2	42%	1,2,3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 13. (2)

(*) Provided via Moodle; 2 weeks before the official release of the project.
(2) Students can expect the marks to be available in less than two weeks (after submission).

Assignments

Presentation

All programs and results must be explained to your demonstrator. A significant portion of the marks are for your knowledge demonstrated during your meeting with the demonstrator.
A short quiz (for all the students in a lab session), before the demonstration, may be required. 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 the demonstrations, you must submit all your software and report (if required) in a zipped file, via a Moodle submission site, before midnight of the Friday of the week the assignment is assessed. Details about the format and name convention for programs files and reports will be explained 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. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor ***before the due date***. Special consideration for assessment tasks of 20% or greater 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.

Examinations

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

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.

6. Expected Resources for students

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

In addition to the real-time data provided by the sensors/platforms in the lab, datasets of typical measurements (3D camera, inertial unit, servos) are provided for allowing the students to perform play-back sessions and even work at home for solving certain parts of the projects.

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final class for the course, Moodle's forums 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:
New platform, fully operational being used in the projects (hexapods). In addition to the perception part, the new projects involve actuation of the platforms.

8. 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.

9. Administrative Matters

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 E. Guivant
21 February 2016

Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

	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