Course outline

Semester 1 2017

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MTRN4010

ADVANCED AUTONOMOUS SYSTEMS

Contents

1. Staff contact details

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

Contact hours

	Day	**Time**	**Location**
Lecture	Monday	10:00 – 12:00	Colombo Theatre B
Projects/ Lab	Monday	13:00 – 16:00	Mechatronic Lab 212 (J18)
	Tuesday	09:00 – 12:00	Mechatronic Lab 212 (J18)
	Tuesday	12:00 – 15:00	Mechatronic Lab 212 (J18)
	Wednesday	15:00 – 18:00	Mechatronic Lab 212 (J18)
	Thursday	15:00 – 18:00	Mechatronic Lab 212 (J18)

Summary of the course

The course is aimed at learning basic and advanced techniques necessary for the sensing and control of autonomous systems. Contents covered in this course are the theory and application of topics such as Stochastic Processes, Bayesian State Estimation (including Kalman Filter, Extended Kalman Filters), Sensor Data Fusion, Fuzzy Logic, Particle Swarm Optimization (PSO) and Neural Networks. 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

The following are the course objectives:

- Understanding of the problem of Modelling and Estimation of Stochastic Dynamical

Processes, in particular for Robot Perception and Localization.

- Understanding the Implementation of stochastic Sensor Data Fusion for solving Engineering Problems.
- Understanding the theory of advanced techniques such as Fuzzy Logic, PSO and Neural Networks.
- Be able to implement simulations and real systems for the control and estimation of processes such as a mobile robotic platform.
- Enable students to work to improve problem-solving skills.
- Obtain experience working with current state of the art sensing technology in Field Robotics.

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 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.	Understand the general theory of Bayesian Estimation. Understand the theory and application of the Kalman Filter (KF and EKF) for solving diverse types of problems in the area of Engineering	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
2.	Understand methods such as Neural Networks, Fuzzy Logic and PSO.	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
3.	Be able to develop software for applying the theory and actually solving complex problems. Have experience in using state of the art sensors, used in Field Robotics and Autonomous Systems	PE2.3 Application of systematic engineering synthesis and design processes

3. 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 all the guidance and assistance in managing the laboratory tasks.

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

4. Course schedule

Topic	Date	Location*	Lecture Content	Suggested Readings
Introduction / refreshing concepts	week 1	LR	Refreshing concepts: Statistics (Random variables, probability density functions), state space representation, matrix/vector operations and Matlab plain programming language	Moodle lecture notes
Typical Sensors and Models	week 2	LR	Sensors used in the projects: 3D Inertial Measurement Unit (IMU). Laser Scanners (Sick LMS2XX, LMS1XX, Hokuyo, 3D Velodyne). Other usual sensors used in Mobile Robotics. Process Models for mobile platforms.	Moodle lecture notes
Estimation 1	week 3	LR	Study of Bayesian Estimation, Sensor Data Fusion.	Moodle lecture notes
Estimation 2	week 4	LR	(Continuation of previous topic)	Moodle lecture notes
Estimation 3	week 5	LR	Gaussian Estimators: Kalman Filter and Extended Kalman Filter (EKF)	Moodle lecture notes
Estimation 4	Week 6	LR	Examples using EKF for estimation (not just for Robotics).	Moodle lecture notes
Localization 1	week 7	LR	Applying EKF in Robotics: Solving the localization of a UGV. Fusing IMU, encoders and laser scanner sensors.	Moodle lecture notes
Localization 2	week 8	LR	Alternative approach: Applying an optimizer for solving the localization problem	Moodle lecture notes

Special Topic	week 9	LR	Case of Study: SLAM (Simultaneous Localization and Mapping) or similar problem (to be decided by students).	Moodle lecture notes
PSO	week 10	LR	Introduction to PSO (Particle Swarm Optimization)	Moodle lecture notes
Neural Networks	week 11	LR	Introduction to Neural Networks	Moodle lecture notes
Fuzzy Logic	week 12	LR	Introduction to Fuzzy Logic	Moodle lecture notes
Revision	week 13	LR	Revision and discussion	Moodle lecture notes

*Note: LR = lecture Room = Colombo Theatre B

5. 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%	1,3	Refer to assignments 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	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 (of Project component)	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Task 0	Problems	0%	(refreshing concepts and skills)	No assessment	---	N/A	N/A
Task 1	Completely operational software	9%	3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 5.	1 week later	< 10 days later
Task 2	Completely operational software	9%	3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 7.	1 week later	< 10 days later
Project 1	Completely operational software	40%	1,3	Refer to assignment specification for exact details (*)	Meeting with a demonstrator during week 10.	1 week later	< 10 days later
Project 2	Completely operational software	42%	1,3	Refer to assignment specification for exact details (*).	Meeting with a demonstrator during week 12.	1 week later	< 10 days later

(*) Provided via Moodle; 2 weeks before the official release of the project.

Assignments

All programs and results must be explained to your demonstrator. A significant portion of the marks are the result of your knowledge demonstration, during your meeting with the demonstrator.

A short quiz (for all the students in a lab session), before the demonstration, is usually 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 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 specified with the release of the tasks and projects.

Presentation

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

Late submissions will be penalised up to 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.

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

You must be available for the final examination. Final examination for this course is held during the University examination period.

Provisional Examination timetables are generally published on myUNSW in May, for Semester 1.

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, datasets of typical measurements are provided for allowing the students to perform play-back sessions and work at home when needed.

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.

One starting point for assistance is: https://www.library.unsw.edu.au/

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the myExperience 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

- Introducing state of the art sensors, such the ones used in autonomous cars.
- The UGV platform will be available in an earlier stage (week 3).
- The practical component of the course has been adapted for providing skills and experience in line with the state of the art of the related area of Engineering.

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.

Although students are encouraged to discuss concepts with colleagues, the work in the projects is INDIVIDUAL. Programs and reports are individual work.

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 Guivant
01/February/2017

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