UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 1 2019

MTRN4010

ADVANCED AUTONOMOUS SYSTEMS

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

Contact details and consultation times for additional lecturer

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.

Contact details and consultation times for demonstrators/lab staff

Please see the course Moodle.

2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre

3. Course details

Credit points

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

Contact hours

	Day	Time	Location
Lectures	Tuesday	18:00 -20:30	Colombo Theatre A (B16-LG03)
(Web stream)	Any	Any	Moodle
Lab/Tutorials	Enrolment specific (*)	(*)	Mechatronic Lab 212 (J18)

(*) Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes. If you need additional time, please contact the Lecturer to organize possible extra lab sessions.

Summary and Aims 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, at the end of the session, a real platform (UGV-Unmanned Ground Vehicle).

The following are the course objectives:

- Understanding of the general problem of Modelling and Estimation of Stochastic Dynamic Processes.
- Understanding the Implementation of stochastic Sensor Data Fusion for solving Engineering Problems.
- Using those concepts for a real application: Robot Perception and Localization.
- 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 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 learning outcomes below 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.	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
2.	Understand methods such as Neural Networks, Fuzzy Logic and PSO.	PE1.1
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

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

Date	Topic	Loc.	Lecture Content	Suggested Readings
week 1	Introduction / refreshing concepts	LR	Refreshing concepts: Statistics (Random variables, probability density functions, etc.), state space representation, matrix/vector operations. Examples in Matlab plain programming language.	Moodle lecture notes (*)
weeks 1,2	Typical Sensors and Models	LR	Process Models for mobile platforms. Typical sensors used in our projects.	Moodle lecture notes
weeks 2,3	Estimation 1&2	LR	Bayesian Estimation, Sensor Data Fusion.	Moodle lecture notes

Date	Topic	Loc.	Lecture Content	Suggested Readings
week 4	Estimation 3	LR	Gaussian Estimators: Kalman Filter and Extended Kalman Filter (EKF)	Moodle lecture notes
Week 5	Estimation 4	LR	Examples using EKF for estimation (not only for Robotics).	Moodle lecture notes
week 5	Localization 1	LR	Applying EKF in Robotics: Solving the localization of a UGV. Fusing IMU, encoders and LIDAR sensors. Alternative approach: Applying an optimizer for solving the localization problem	Moodle lecture notes
week 6	Fuzzy Logic	LR	Fuzzy systems, mobile robot motion control	Moodle lecture notes
week 7	Neural networks	LR	Neural networks, modelling of complicate autonomous system	Moodle lecture notes
week 8	Metaheuristics	LR	Metaheuristics; genetic algorithm, particle swarm optimizer	Moodle lecture notes
week 9	Intelligent Control	LR	Optimization of fuzzy control systems	Moodle lecture notes
week 10	Reviews/ discussion		Review of concepts. Discussion of future work. Demos of industrial projects using methods applied in MTRN4010.	N/A

Note: LR = Lecture Room = Colombo Theatre A (B16-LG03)
Note (*): Lecture notes are produced and provided by the lecturers.

6. Assessment

Assessment overview

Assessment task	Group Project?	If Group, number of Students per group	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Projects	No	N/A	4 projects	50%	1,2,3	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	No	N/A	2 hours	50%	1,2,3	All course content from weeks 1-10	Exam period, date TBC.	N/A	Upon release of final results

Additional necessary conditions, in order to pass the course:

a) The exam mark must be 40/100 or higher
b) b) The total mark of the project component must be 40/100 or higher

Project overview

All the projects are specified to be individual work.

Project task	Group Project?	If Group, number of Students per group	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Task 0	No	N/A	Problems	0%	Refreshing concepts.	No assessment	---	N/A	N/A

Project task	Group Project?	If Group, number of Students per group	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date, time, and submission requirements	Deadline for Absolute fail	Marks returned
Task 1	No	N/A	Completely operational software	10%	3	Refer to assignment specification for exact details (note 1).	Meeting demonstrator, week 4(*).	1 week later	< 10 days later
Task 2	No	N/A	Completely operational software	20%	3	Refer to assignment specification for exact details (note 1).	Meeting demonstrator, week 6(*).	1 week later	< 10 days later
Task 3	No	N/A	Completely operational software	35%	1,3	Refer to assignment specification for exact details (note 1)	Meeting demonstrator, week 8 (*).	1 week later	< 10 days later
Task 4	No	N/A	Completely operational software	35%	2	Refer to assignment specification for exact details (note 1).	Meeting demonstrator, week 9 (*).	1 week later	< 10 days later

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

Note 2: (*) During your nominal lab session, that week.

In addition, all the projects will be released well in advance (3 weeks in advance, at least) before the submission dates.

Task demonstrations may be preceded by a short quiz, whose result would be part of the marking scheme for the task. For each task, the 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 the 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 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. 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. For some projects, the quiz will be performed ON-LINE, via Moodle, at a different time.

At the end of each demonstration, you must submit your software and report (if required) in a zip 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.

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

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 per cent (20%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the ‘deadline for absolute fail’ is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by 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. Pass/Fail assessment tasks.

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 duration of the exam 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: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates.

For further information on exams, please see the Exams webpage.

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 available 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 Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that has interfered with your assessment performance, you are eligible to apply for Special Consideration. For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW’s Special Consideration page.

7. 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.

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

8. 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. The course convenor has negotiated proper access to an additional lab (211), so that MTRN4010's students can also use it, in case they need more time.
- More examples using EKF in areas which are not Robotics.
- Tutors: better coverage of lab hours (guaranteed 2 tutors/session, at all times).
- MTRN4010 and MTRN4110 (Robot Design) are not offered in the same session anymore; that used to be a concern for many students who considered the situation resulted in an extremely high workload.

9. 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, visit: 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

10. 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
- UNSW Email Address
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

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