UNSW AUSTRALIA

# Course Outline

Semester 1 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

# MTRN4010
# Advanced Autonomous Systems

# MTRN9222
# Artificially Intelligent Machines

# Contents

# Course Outline

# MTRN4010 Advanced Autonomous Systems

## 1. COURSE STAFF

### Contact details and consultation times for the lecturer

Dr Jose E Guivant
Room 303, Building H6
Tel (02) 9385 9820
Fax (02) 9663 1222
Email j.guivant@unsw.edu.au

Consultation times with Dr Guivant will be decided later, in agreement with the students' timetables. Discussions in Moodle's forums are also strongly recommended.

## 2. COURSE DETAILS

### Units of credit

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

For a standard 24 UoC in the semester, this means 600 hours, spread over an effective 15 weeks of the semester (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade. Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case.

Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 4 h/w of your own time. This should be spent in making sure that

you understand the lecture material, completing the set assignments, further reading about the course material, and revising and learning for the examination.

**Timetable**

Lectures : Tue 16:00 - 18:00 - Electrical Eng. 224 (K-G17-224)

Problem solving classes / Laboratory sessions (*):
[Thu 12:00 - 15:00],[Thu 15:00 - 18:00],[Wed 09:00 - 12:00],[Wed 12:00 - 15:00]
G6-G10B Mechatronics Lab. (Blockhouse)
(*) One of the four available sessions.

**Description:**

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, State Estimation, Sensor Data Fusion, Fuzzy Logic, Particle Swarm Optimization (PSO), Genetic Algorithms.
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.
* Understand the Implementation of stochastic Sensor Data Fusion for solving Engineering Problems.
* Understanding the theory and application of advanced techniques such as Fuzzy Logic, PSO and Genetic Algorithms.
* 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.

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

**Graduate attributes**

UNSW's graduate attributes are shown at
https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students.

UNSW graduates will be

1. Scholars who are:
   - (a) understanding of their discipline in its interdisciplinary context ✓
   - (b) capable of independent and collaborative enquiry ✓
   - (c) rigorous in their analysis, critique, and reflection ✓
   - (d) able to apply their knowledge and skills to solving problems ✓
   - (e) ethical practitioners
   - (f) capable of effective communication ✓
   - (g) information literate ✓
   - (h) digitally literate ✓

2. Leaders who are:
   - (a) enterprising, innovative and creative
   - (b) capable of initiating as well as embracing change
   - (c) collaborative team workers

3. Professionals who are:
   - (a) capable of independent, self-directed practice ✓
   - (b) capable of lifelong learning ✓
   - (c) capable of operating within an agreed Code of Practice

4. Global Citizens who are:
   - (a) capable of applying their discipline in local, national and international contexts
   - (b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways
   - (c) capable of environmental responsibility

   ✓ = Developed in this course

In this course, you will be encouraged to develop graduate attributes 1(a), 1(b), 1(c), 1(d), 1(f), 1(g), 1(h), 3(a) and 3(b) by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment tasks.

You will be supported in developing the above attributes through:
(i) the design of academic programs;
(ii) course planning and documentation;

(iii) learning and teaching strategies; and
(iv) assessment strategies.

## 3. TEACHING STRATEGIES

Lectures in the course are designed to provide a rich theory about the concepts taught. In addition, a number of examples will be presented as well, in order to illustrate the significance of the theory. For most classes lecture notes will be available on-line and beforehand. Students are encouraged to ask questions during the classes.
Problem solving classes and projects are designed to provide the student with the practical aspects of the concepts presented in the lectures. Students have the opportunity to test their implementations working with real data, provided by complex robotic platforms.

## 4. ASSESSMENT

### General

You will be assessed by way of assignments and a final examination.

The composition of the total mark will be as follows:

| | |
|---|---|
| Final Examination | 50%(*) |
| Assignments/Projects (total) | 50%(*) |
| **Total** | **100%** |

(*) In order to pass the subject, the total mark must be not less than 50%. Additionally, the exam's mark must be not less than 45/100 and the total mark of the practical component not less than 50/100. Both components need to be passed. Passing just one component is not "sufficient condition" to pass the subject, even if the total mark is 50% or higher.

All marks (tasks, projects, exam) will be always individually expressed in scale [0:100].

### Assignments

Electronic copies of the assignments and projects will be available on the Moodle website. The list of assignments and related deadlines are expressed in the table of projects and problem solving classes.

Submission

Assignments are due on the day and time that will be properly announced (at the release of the assignments). Submission will be electronic (pdf files and Matlab programs). No hard copy versions will be required.

Late submission of assignments attracts a penalty of **20% (of the assignment mark) per day**, unless prior dispensation has been given.

**Examination**

There will be an examination at the end of the semester. The exam will have a duration of two hours. It will cover all the material (theory and practice) developed during the session.

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. The list of approved calculators is shown at https://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 *Administrative Matters for All Courses*, available from the School website.

## 5. TOPICS.

**Lectures**

| **Week** | **Topic** |
|---|---|
| Week 1 | Introduction. Sensors used in our projects: Inertial Measurement Unit (IMU). Laser Scanner. Other usual sensors used in Mobile Robotics. Process Models for mobile platforms. |
| Week 2 | Refreshing necessary concepts: Statistics (Random variables, probability density functions), state space representation, matrix/vector operations and Matlab programming language. |

| | |
|---|---|
| Weeks 3,4,5 | Study of Bayesian Estimation – Sensor Data Fusion. Gaussian Estimators: Kalman Filter and Extended Kalman Filter (EKF). |
| Weeks 6,7 | Data Fusion applied to robot's Localization and Mapping. |
| Weeks 8 | Case of study: SLAM (Simultaneous Localization and Mapping) |
| Weeks 9 | Fuzzy Logic. Application to control. |
| Weeks 10 | Genetic Algorithms. Application to Path Planning. |
| Weeks 11 | Particle Swarm Optimization (PSO) |
| Weeks 12 | Revision |

**Projects, Problem solving classes and Laboratory Work**

| | |
|---|---|
| Week 2: | Preparing skills for the projects: Solving Problems using Matlab. Using Matrices/Vectors. Plotting Results, Etc. |
| Week 3: | Work solving Task 01.(Processing IMU's measurements) |
| Weeks 4,5: | Work solving Task 02.(Processing Laser Scanner's measurements). |
| Week 5: | Brief **demonstration** (*) of implementations and results of Tasks01 and Task02. |
| Week 6: | Work on Taks03: on-line versions of Task01 and task02. |
| Week 7: | Brief **demonstration** of implementations and results of Task03. Work on implementing Kalman Filter estimators for simple problems. |
| Week 8,9 | Work on Project01, "Implementing a Localizer based on EKF". Off-line and On-line versions. |
| Week 10 | **Demonstration** of implementations and results of Project01. (Report of Project01 to be submitted by Monday on week 11) Start working on Project02. |
| Week 11 | Problem solving class problems using FL. Continue working on Project02. |
| Week 12 | Problem solving class problems using GA. **Demonstration** of implementations and results of Project02. (Report of Project02 to be submitted by Wednesday on week 13) |
| Week 13 | Problem solving class problems using PSO. |

Relevance of tasks and projects
(Expressed as a percentage of the practical component of MTRN4010)

| | |
|---|---|
| Task01 | 5% |
| Task02 | 6% |

| | |
|---|---|
| Task03 | 5% |
| Project01 | 42% |
| Project02 | 42% |

This schedule may be subject to change at short notice, to suit exigencies.

(*): "Brief demonstration": During approximately 5 minutes, the student shows his/her implementation (usually a program) and explains results. The evaluator (demonstrator/lecturer) may ask questions about concepts and details related to the project.

"Demonstrations" are usually more intense, where the student may be asked to answer more questions about the presented results, program code and necessary concepts. A situation where a student does not understand/know his/her program code is considered an important demerit.

## 6. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

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 a honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is presented in *Administrative Matters,* available on the School website.

## 7. RESOURCES FOR STUDENTS

**Lecture notes:** Electronic copies of lecture notes, book chapters and research papers will be provided via MTRN4010's Moodle site

**Equipment:** Sensors, robot's data and desktop computers are provided in the Laboratory. Students are allowed to use their personal laptops (provided that the students have an installed version of Matlab). Software and libraries for communication with the sensors and robots will be provided.

## 8. 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 via forums in Blackboard/Moodle, 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.

A new set of lecture notes will be released this year and a clear and strict schedule for the demonstration of projects will be followed. More examples (in other areas not related to Robotics) for KF and EKF, will be released.

## 9. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with *Administrative Matters*, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

*Jose Guivant, 10 February 2015*