Mtrx 4700/5700: Experimental Robotics

Unit of Study Description

6 credit points.
Classes: 2 hr lecture and a 3 hr lab/wk.
Assessment: Assignments, lab work and a project presentation.
Fourth year elective unit of study for Mechatronic Engineering

Syllabus Summary:

This Unit of Study presents a broad overview of the technologies associated with industrial and mobile robots. Major topics covered include sensing, mapping, navigation and control of mobile robots and kinematics and control of industrial robots. The subject consists of a series of lectures on robot fundamentals and case studies on practical robot systems. Material covered in lectures is illustrated through experimental laboratory assignments.

Unit of Study Aims/Goals:

The objective of the course is to provide students with the essential skills necessary to develop robotic systems for practical applications.

Student Learning Outcomes:

Following completion of this UoS students will:

1. Be familiar with sensor technologies relevant to robotic systems
2. Understand conventions used in robot kinematics and dynamics
3. Understand the dynamics of mobile robotic systems and how they are modeled
4. Have implemented navigation, sensing and control algorithms on a practical robotic system
5. Apply a systematic approach to the design process for robotic systems
6. Understand the practical application of robotic systems in applications such as manufacturing, automobile systems and assembly systems
7. Develop the capacity to think creatively and independently about new design problems
8. Undertake independent research and analysis and to think creatively about engineering problems

Graduate Attributes

The University of Sydney has a set of generic attributes which it believes a graduate should attain upon completion of their degree which will provide them with the opportunity of being “more employable, more able to cope with change and more developed as people”.

This Unit of Study will provide students with opportunity to further develop the following generic attributes:

1. Research and Inquiry – through an appreciation of engineering fundamentals that are based upon the principles and knowledge of science and mathematics. Opportunities to apply these fundamentals along with the basics of science and mathematics to engineering problem solving will be provided through hands-on experimentation. Students will also be given the opportunity to design and conduct experiments and to analyse and interpret data from those experiments.

2. Information Literacy – through a variety of information sources within the engineering discipline including technical books and reports, research articles and requirements documents.
3. **Personal and Intellectual Autonomy** – through an appreciation for the role of creative thinking within engineering and the ability to undertake and indulge in this process. Students will also be required to function effectively as an individual even within the context of teamwork, and to understand the importance of the role of an individual within group situations.

4. **Ethical, Social and Professional Understanding** – in particular the ability to value your own engineering judgments through the process of engineering design.

5. **Communication** – through opportunities to develop effective communication techniques that emphasize clear and concise presentation of ideas, concepts and solutions to both technical and non-technical audiences. Students will work in small groups on laboratory experimentation and hence will be required to develop a commitment to, and fundamental appreciation of, the concept of successful teamwork and the ability to communicate effectively, clearly and concisely as a team leader or member of a group.

### Learning Situations

Teaching in this UoS will consist of one two hour lecture and three hours of laboratory time. The series of lectures will cover robot fundamentals and case studies examining practical robot systems. Experts in the field will be invited to present guest lectures to give the students a broad exposure to robotic systems both in research and industrial contexts. The lecture will be held in **Mech TR1 on Tuesdays from 9-11**.

Material covered in lectures is illustrated through experimental laboratory assignments. By applying the techniques they have learned, students will be given the opportunity to contextualize their learning. Application of the concepts will encourage a deeper approach to their learning. Labs will be conducted once a week in the **Mechatronics Lab L325 on Fridays from 9-12**.

Finally, students will be asked to present a demonstration of their major project to other students and staff. This will encourage them to produce a system of sufficient quality that they can demonstrate it to their peers. This will also provide the students with an opportunity to share their experiences with their classmates.

### Assessment:

Assessment in this Unit of Study will be based on assignment and laboratory work, an end of semester exam and a presentation and report describing a major research assignment. Labs will be conducted once a week. The use of laboratory work will allow students to apply their newfound knowledge of robotic systems to a variety of practical systems. The introductory labs are designed to familiarize students with the material required to prepare for the major laboratory project. Course evaluation will consist of the following:

- **Introductory Labs (30%)**
  - Manipulator Lab: Due Week 4 (10%)
  - Sensing Lab: Due Week 7 (10%)
  - Navigation Lab: Due Week 9 (10%)
- **Major Project Presentation and Report (40%)**
- **Exam (30%)**

The following grade descriptors specify the standard of work that is expected from you to achieve the following grade levels.
<table>
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<tr>
<th>Grade Level</th>
<th>Descriptor</th>
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<tr>
<td>High Distinction</td>
<td><strong>Work of exceptional standard.</strong> Work demonstrates initiative and ingenuity in research, pointed and critical analysis of material, thoroughness of design, and innovative interpretation of evidence. Demonstrates a comprehensive understanding of the unit material and its relevance in a wider context.</td>
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| Distinction          | **Work of superior standard.** Work demonstrates initiative in research and reading, complex understanding and original analysis of subject matter and its context, both empirical and theoretical; shows critical understanding of the principles and values underlying the unit of study. In particular, students who aim for a Distinction and higher will have to accomplish the requirements of a Credit and should be able to:  
  • Generalise algorithms to more complicated systems not dealt with explicitly in class.  
  • Demonstration of independent research and in-depth understanding of material beyond the scope of the lecture material.  
  • Synthesise and analyse various components of a robotic system using a systems engineering approach in order to develop and demonstrate a working system.  |
| Credit               | **Competent work.** Evidence of extensive reading and initiative in research, sound grasp of subject matter and appreciation of key issues and context. Engages critically and creatively with the question and attempts an analytical evaluation of material. Goes beyond solving of simple problems to seeing how material in different parts of the unit of study relate to each other by solving problems drawing on concepts and ideas from other parts of the unit of study. In particular, students who aim for a Credit will have to accomplish the requirements of a Pass and should be able to:  
  • Relate between the various components of the course and understand their interaction in terms of integration of robotic systems.  
  • Manipulate kinematic and dynamic equations related to manipulator and mobile robotic systems.  
  • Implement and demonstrate advanced robotic concepts as described in theoretical works studied as part of the course.  |
| Pass                 | **Work of acceptable standard.** Work meets basic requirements in terms of reading and research and demonstrates a reasonable understanding of subject matter. Able to solve relatively simple problems involving direct application of particular components of the unit of study. In particular, students who aim for a Pass should be able to:  
  • Identify the various components of a robotic system.  
  • Use simple equations for problem solving in robotic systems.  |
| Fail                 | **Work not of acceptable standard.** Work may fail for any or all of the following reasons: unacceptable level of paraphrasing; irrelevance of content; presentation, grammar or structure so sloppy it cannot be understood; submitted very late without extension; not meeting the University’s values with regards to academic honesty.  |

**Unit of Study References:**
There is no prescribed text for this course. Recommended reading and references will be provided in relation to assignments. You may also wish to consult the following texts to help you in your understanding of the material related to this course.

**Manipulator Kinematics and Dynamics**
Computer Vision
- Ballard and Brown, *Computer Vision*, Prentice Hall, 1982

Machine Learning

Mobile Robotics

Unit of Study Program:

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Content</th>
<th>Labs</th>
<th>Due Dates</th>
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<tbody>
<tr>
<td>1</td>
<td>5 Mar</td>
<td>Introduction, history &amp; philosophy of robotics</td>
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<tr>
<td>2</td>
<td>12 Mar</td>
<td>Robot kinematics &amp; dynamics</td>
<td>Kinematics/Dynamics Lab</td>
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<td>3</td>
<td>19 Mar</td>
<td>Sensors, measurements and perception</td>
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<td>4</td>
<td>26 Mar</td>
<td>Robot vision and vision processing.</td>
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<td>5</td>
<td>2 Apr</td>
<td>BREAK</td>
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<td>6</td>
<td>9 Apr</td>
<td>Localization and navigation</td>
<td>Sensing with lasers</td>
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<td>7</td>
<td>16 Apr</td>
<td>Estimation and Data Fusion</td>
<td>Sensing with vision</td>
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<tr>
<td>8</td>
<td>23 Apr</td>
<td>Extra tutorial session (sensing)</td>
<td>Robot Navigation</td>
<td>Sensing Lab</td>
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<tr>
<td>9</td>
<td>30 Apr</td>
<td>Obstacle avoidance and path planning</td>
<td>Robot Navigation</td>
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<tr>
<td>10</td>
<td>7 May</td>
<td>Extra tutorial session (nav demo)</td>
<td>Major project</td>
<td>Navigation Lab</td>
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<tr>
<td>11</td>
<td>14 May</td>
<td>Robotic architectures, multiple robot systems</td>
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<td>12</td>
<td>21 May</td>
<td>Robot learning</td>
<td>&quot;</td>
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<td>13</td>
<td>28 May</td>
<td>Case Study</td>
<td>&quot;</td>
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<td>14</td>
<td>4 June</td>
<td>Extra tutorial session (Major Project)</td>
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<td>Major Project</td>
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Staff Contact Information

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<tr>
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<td>ACFR</td>
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