Welcome to Robotics!
History of Humanoids
Men's dream takes first step forward
Agenda

- Course Objectives
- Robotics Domain Overview
- System Design Principles

Schedule of Events

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lecture (M: 12-1:30, 43-102)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23-Jul</td>
<td>Introduction</td>
</tr>
<tr>
<td>2</td>
<td>30-Jul</td>
<td>Representing Position &amp; Orientation &amp; State Frames, Transformation Matrices &amp; Affine Transformations</td>
</tr>
<tr>
<td>3</td>
<td>6-Aug</td>
<td>Robot Kinematics and Dynamics</td>
</tr>
<tr>
<td>4</td>
<td>13-Aug</td>
<td>Robot Dynamics &amp; Control</td>
</tr>
<tr>
<td>5</td>
<td>20-Aug</td>
<td>Obstacle Avoidance &amp; Motion Planning</td>
</tr>
<tr>
<td>6</td>
<td>27-Aug</td>
<td>Sensors, Measurement and Perception</td>
</tr>
<tr>
<td>7</td>
<td>3-Sep</td>
<td>Localization and Navigation</td>
</tr>
<tr>
<td>8</td>
<td>10-Sep</td>
<td>State-space modelling &amp; Controller Design</td>
</tr>
<tr>
<td>9</td>
<td>17-Sep</td>
<td>Vision-based control</td>
</tr>
<tr>
<td>10</td>
<td>24-Sep</td>
<td>Study break</td>
</tr>
<tr>
<td>11</td>
<td>1-Oct</td>
<td>Uncertainty/POMDPs</td>
</tr>
<tr>
<td>12</td>
<td>8-Oct</td>
<td>Robot Machine Learning (TBA)</td>
</tr>
<tr>
<td>13</td>
<td>15-Oct</td>
<td>Guest Lecture (CSIRO-TBA)</td>
</tr>
<tr>
<td></td>
<td>22-Oct</td>
<td>Wrap-up &amp; Course Review</td>
</tr>
</tbody>
</table>
Assessment

- Kinematics Lab (20%):
  - Proprioception
  - Arm design and operation (with Lego)

- Sensing Lab (25%):
  - Exterioception
  - Camera operation and calibration (with a Kinect)

- Systems and Controls Lab (30%):
  - All together!

- Final Exam (25%) 😊

Lectures

- Mondays from 12:00 – 1:30 pm

- Lectures will be posted to the course website after the lecture (so please attend)

- Please ask questions
  (preferably about the material 😊)
Tutorials & Labs

• Tutorials:
  – Tuesdays from 12:00 – 1:00 in the Axon Learning Lab (47-104)
  – Meeting Weeks 2-9 (not this week!)

• Labs:
  – Fridays from 11:00 – 1:00 in the Axon Learning Lab (47-104)
  – Meeting: Weeks 3-13 (not this week or next week!)

The Teaching Team

• Lecturers:
  Surya Singh, Paul Pounds, and Hanna Kurniawati

• Tutors:
  Mr Ashray, Doshi
  Mr Christopher Ham
  Mr Adam Keyes
  Mr Jared Page
  Mr Ye Tian
### E-mail & website

**metr4202 @ itee.uq.edu.au**

http://robotics.itee.uq.edu.au/~metr4202/

Please use **metr4202** e-mail for class matters!

---

### Course Objectives

1. Be familiar with sensor technologies relevant to robotic systems
2. Understand homogeneous transformations and be able to apply them to robotic systems,
3. Understand conventions used in robot kinematics and dynamics
4. Understand the dynamics of mobile robotic systems and how they are modelled
5. Understand state-space and its applications to the control of structured systems (e.g., manipulator arms)
6. Have implemented sensing and control algorithms on a practical robotic system
7. Apply a systematic approach to the design process for robotic system
8. Understand the practical application of robotic systems in to intelligent mechatronics applications (e.g., manufacturing, automobile systems and assembly systems)
9. Develop the capacity to think creatively and independently about new design problems; and,
10. Undertake independent research and analysis and to think creatively about engineering problems.
The Point of the Course

- Introduction to terminology/semantics
- An appreciation of how to frame problems in an engineering context
- Modeling and learning to trust the model
- Ability to identify critical details from the problem (separate information from trivia)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Level</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail</td>
<td>(&lt;50%)</td>
<td>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.</td>
</tr>
<tr>
<td>Pass</td>
<td>(50-64%)</td>
<td>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.</td>
</tr>
<tr>
<td>Credit</td>
<td>(65-74%)</td>
<td>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.</td>
</tr>
<tr>
<td>Distinction</td>
<td>(75-84%)</td>
<td>Work of superior standard. Work demonstrates initiative in research, 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.</td>
</tr>
<tr>
<td>High Distinction</td>
<td>(85%+)</td>
<td>Work of exceptional standard. 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 of study material and its relevance in a wider context.</td>
</tr>
</tbody>
</table>
Last Year’s Grade Statistics

- ~ 60% received D or HD
- Worry about **learning**, not about marks

What I expect from you

- **Lectures:**
  - Participate - ask questions
  - Turn up (hence the attendance marks)
  - Take an interest in the material being presented

- **Tutorials:**
  - Work on questions before tutorials
  - Use tutorials to clarify and enhance
  - Assignments to be submitted on time
So What is a Robot ????

- A “Smart” Machine …

- A “General Purpose” (Adaptive) “Smart” Machine…

Plan ➔ Sense ➔ Control ➔ Act

“Learning”

Robotics Definition

- Many, depends on context…

“A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.”

(Robotics Institute of America)

It is a machine which has some ability to interact with physical objects and to be given electronic programming to do a specific task or to do a whole range of tasks or actions.

(Wikipedia)

Programmable electro-mechanical systems that adapt to identify and leverage a structural characteristic of the environment

(Surya)
### Types of Robotics Systems

<table>
<thead>
<tr>
<th>Manipulators</th>
<th>Multiple</th>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Manipulator" /></td>
<td><img src="image2.png" alt="Multiple" /></td>
<td><img src="image3.png" alt="Mobile" /></td>
</tr>
</tbody>
</table>

**Enabling Mathematics:**
- Computational Kinematics
- Operational Space
- Behaviour based “Reflexive” control rules
- Probabilistic methods

---

**Sensing**
Perception: Vision

Edges, Segments, Colour, Texture
3D Stereo Vision

Laser Sensors
Processing …
Environment Understanding

Honda Asimov Humanoid
Dynamic Locomotion & Balance …

Action
Driving a Robot
Driving Many Robots

Robot Submarines For Marine Biology
Robot Sniper Training Robots

What’s the Structure?
Robotics: All about structure…

• Robot working in an “unstructured” environment

⇒ Does not have to be dirty to use “field robotics” technology …
⇒ Robotics is about exploiting the structure …

Either by:

• Putting it in from the design (mechanical structure)
• “Learning” it as the system progresses (structure is the data!)

How to DESIGN smart products?
To Create Something “Smart”…
& Design is a Disciplined Way To Do Just That

Be Stupid!
Be stupid!

- When creating something new it is impossible to be an expert – so don’t act like one.

- Keep your ego out of it, be a professional idiot.

- If you are stupid people will teach you everything they know about the problem.

- If you are smart, they will not volunteer information.

- Question conventional wisdom.

Look – Ask – Simplify - Test

1. Identify a need
2. Commit yourself to satisfying the need
3. Ask questions (be "human")
4. Model! (Reduce system to equations)
5. Express, Test, Cycle
1. Identify a need

- *Find a problem you are interested in working on.*
  (It doesn’t not have to be a problem, it can be an opportunity.)

- Learn everything you can about the need (problem).
  (Understand the context)

- Get clear what the problem really is.
2. Commit to satisfying the need

• Question your motivation

• Don’t expect financial rewards if there is no need being satisfied

• Trust your “gut”; follow “wants” not “shoulds.”

3. Ask Questions

• Consider this from the users perspective…
  – Try “you” instead of “me”…

• How to all the parts fit together
  – Think about the “system”

• Identify “root” causes of angst
  – What’s really going on…
  – Why was the “error” there to begin with

• Be wary of a fixed methodology.
4. Model

• Abstraction from Design to Analysis Tools

Mathematical model
Governed by differential equations.
Assumptions on:
- Geometry,
- Kinematics (body motion),
- Kinetics (consider forces),
- Material mechanics (stiffness),
- Boundary conditions, ...

Software Solution

Software Methods

Assessment

Refine

Interpretation of results

Design changes

Change of Physical problem

Improve mathematical model

Refine Analysis

5. ETC: Express, Test, Cycle

• Start generating solutions immediately.

• Save research efforts for parts you can’t make work.

• Express as many ideas as you can.

• Test the ones you are not sure about.
  (Do it cheaply, use “crap-ups”.)

• Test your prototype.
  Abuse your prototype …
  check it under the worst imaginable conditions.

• Modify, test and rebuild, modify, test and rebuild, …
  (keep iterating until time is up.)
This week’s Tutorial …

• **NOT being held this week**

Summary

• An outline of the course structure – details are in the Unit of Study Outline
• Considered and presented a basic definition of a mechatronic system
• A look at the courses which will fulfil the requirements for a Mechatronic Engineering Degree
• Some examples of common mechatronic systems