Introduction to Robotics

METR 4202: Advanced Control & **Robotics**

Dr Surya Singh – UQ Robotics Design Laboratory

Lecture # 1

July 26, 2013

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

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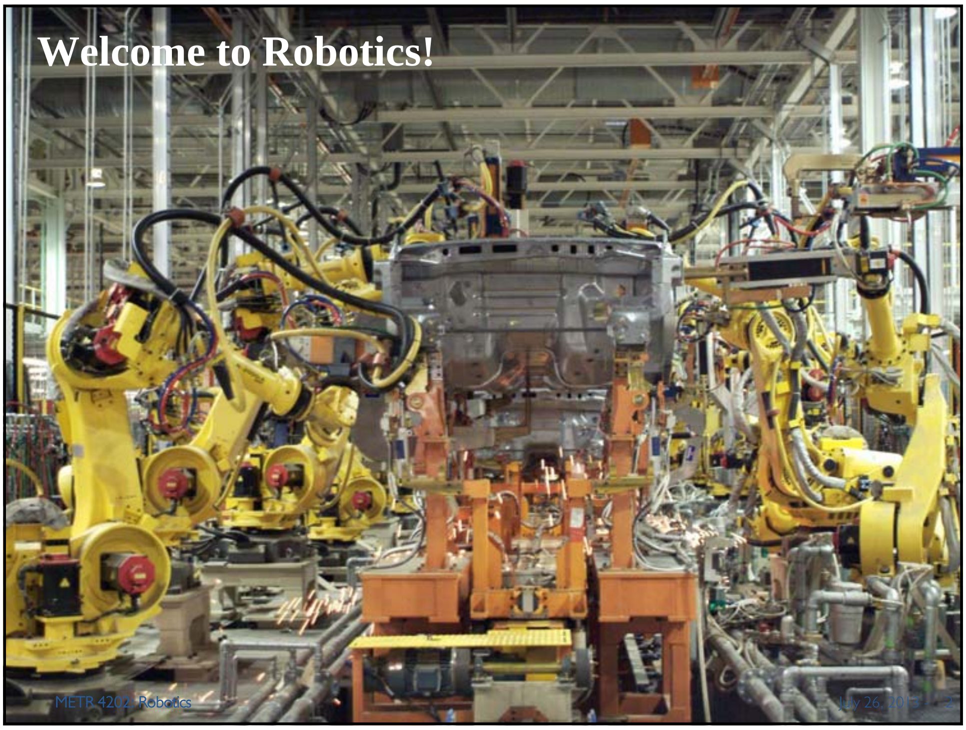
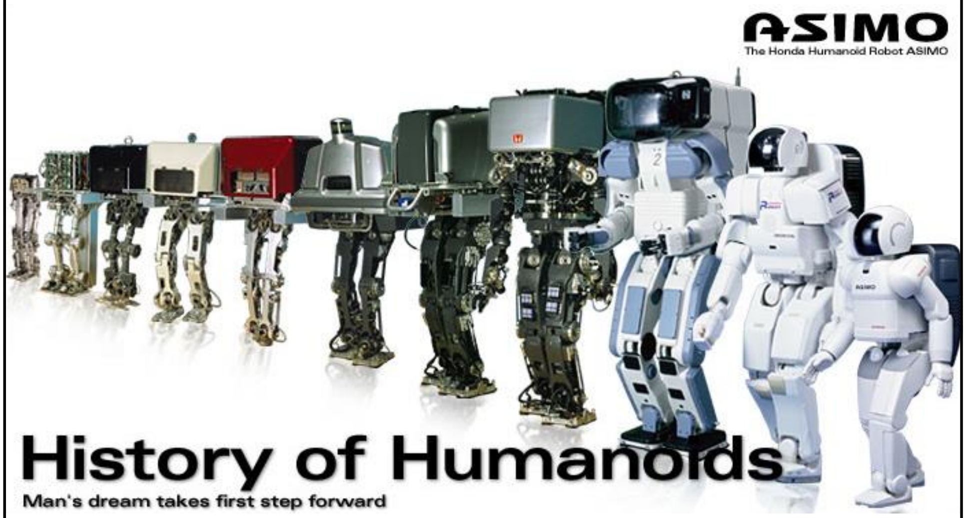
Welcome to Robotics!




ASIMO
The Honda Humanoid Robot ASIMO
History of Humanoids
Man's dream takes first step forward


Powered by Diesel
Red Bull
MDV


METR 4202: Robotics
July 26, 2013 - 5


METR 4202: Robotics
July 26, 2013 - 6

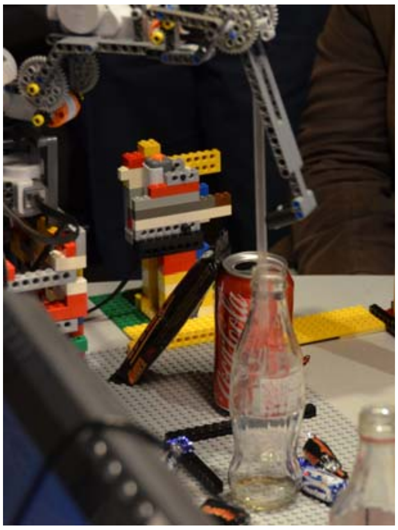

YALE

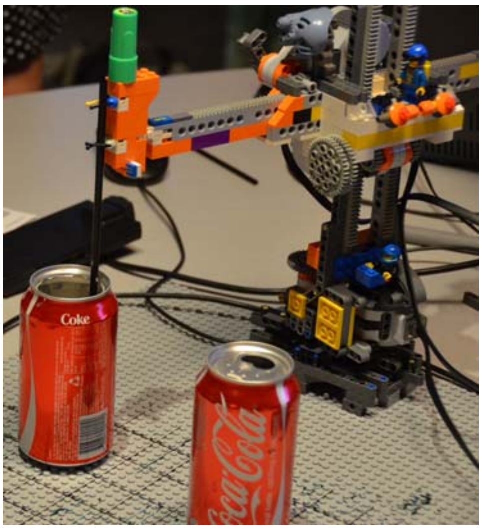
Magicarms


METR 4202: Robotics
July 26, 2013


METR 4202: Robotics
July 26, 2013 - 10

Sweet Explorations





Agenda

- Course Objectives
- Robotics Domain Overview
- System Design Principles

Schedule of Events

Week	Date	Lecture (F: 9-10:30, 50-T103)
1	26-Jul	Introduction
2	2-Aug	Representing Position & Orientation & State (Frames, Transformation Matrices & Affine Transformations)
3	9-Aug	Robot Kinematics and Dynamics
4	16-Aug	Robot Dynamics & Control
5	23-Aug	Sensors & Perception
6	30-Aug	Computer Vision (Image Processing)
7	6-Sep	Computer Vision (Pixels & Features)
8	13-Sep	State-Space Modelling
9	20-Sep	State-Space Control
	27-Sep	Vision-based control (+ Prof. P. Corke or + Prof. M. Srinivasan)
10	4-Oct	*Study break*
11	11-Oct	TBA: Motion Planning or Artificial Intelligence
12	18-Oct	TBA: Underactuated Systems or POMDPs
13	25-Oct	Applications in Industry (+ Prof. S. LaValle) & Course Review

Assessment

- Kinematics Lab (20%):
  - Proprioception
  - Arm design and operation (with Lego)
- Sensing & Control Lab (30%):
  - Exterioception
  - Camera operation and calibration (with a Kinect)
- Advanced Controls & Robotics Systems Lab (40%):
  - All together!
- **Individual** Final Take-Home Quiz (10%) ☺

Lectures

- Fridays from 9:00 – 11:00 am
- Lectures will be posted to the course website **after** the lecture (so please attend)
  - Slides are like dessert – enjoy afterwards!
- Please ask questions
  (preferably about the material ☺)

Tutorials & Labs

- Tutorials:
  - Wednesday from 9:00 – 10:00 in the Axon Learning Lab (47-104)
  - Meeting Weeks 2-9 (not this week!)

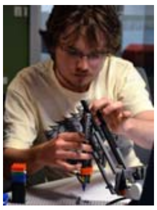
- Labs:
  - Thursdays from 2:00 – 5:00 **<u>or</u>** Wednesdays from 1:00 – 4:00 in the Axon Learning Lab (47-104)
  - Meeting: Weeks 3-13 (not this week or next week!)

The Teaching Team

- Lecturer:
  Surya Singh

- Tutors:

Adam Keyes



Mike Reed

Jaco Du Plessis

?

TBA

The Teaching Team

- The Masters of the RDL
  (& Masters of Ceremony):
  Paul Pounds & Hanna Kurniawati

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.

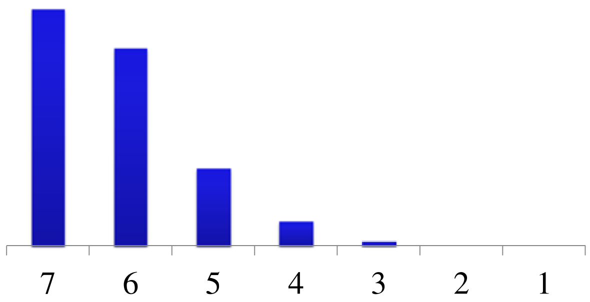
The Point of the Course

- 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)

Grade Descriptors

Grade	Level	Descriptor
Fail	(<50%)	**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.
Pass	(50-64%)	**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.
Credit	(65-74%)	**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.
Distinction	(75-84%)	**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.
High Distinction	(85%+)	**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.

Last Year's Grade Statistics



- ~ 80 % received D or HD
- Worry about **learning**, not about marks [Seriously!]
- Though a "7" might be bit more exclusive

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

- Manipulators

- Mobile

- Adaptive

Enabling Mathematics:

- Computational Kinematics
- Operational Space

- Behaviour based “Reflexive” control rules

-Probabilistic methods

Types of Robotics Systems → Textbooks

- Manipulators

- Roth
- Craig
- S&S
- Asada & Slotine
- Tsai

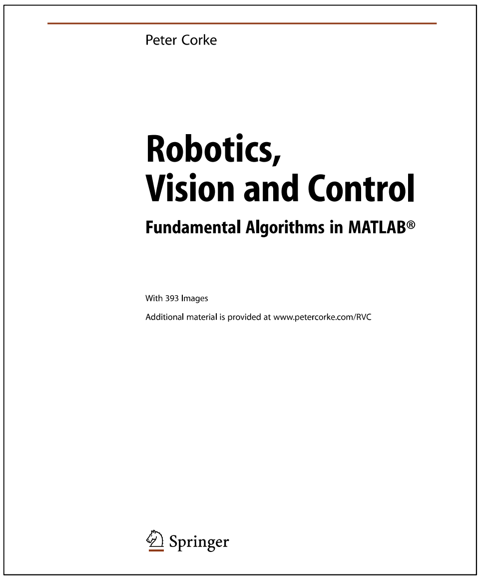
- Mobile

- Corke
- Dillman
- Choset, Thrun, *et al.*
- [SLAM]

- Adaptive

- LaValle
- Thrun
- [[Model] **Predictive** Operations]

Textbook



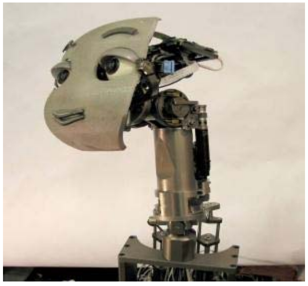
Robotics, Vision and Control Fundamental Algorithms in MATLAB

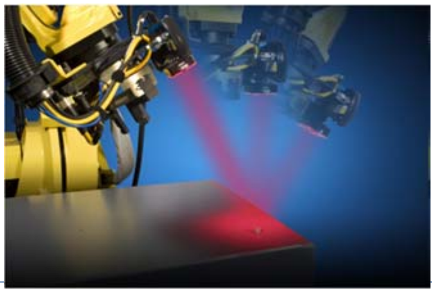
By:
Peter Corke

Available online (on campus) via SpingerLink

Sensing

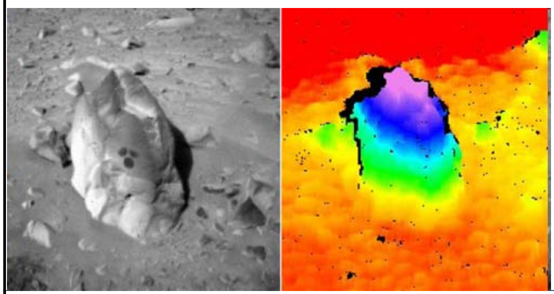
Perception: Vision

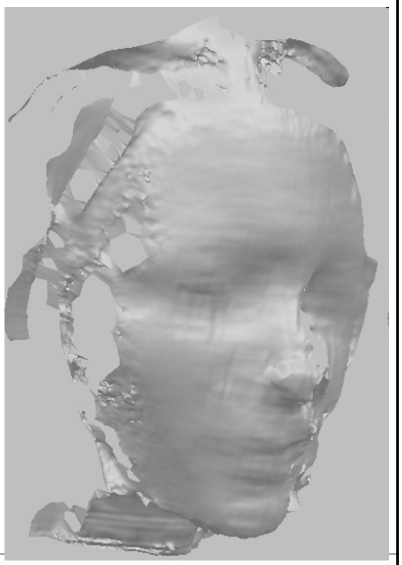




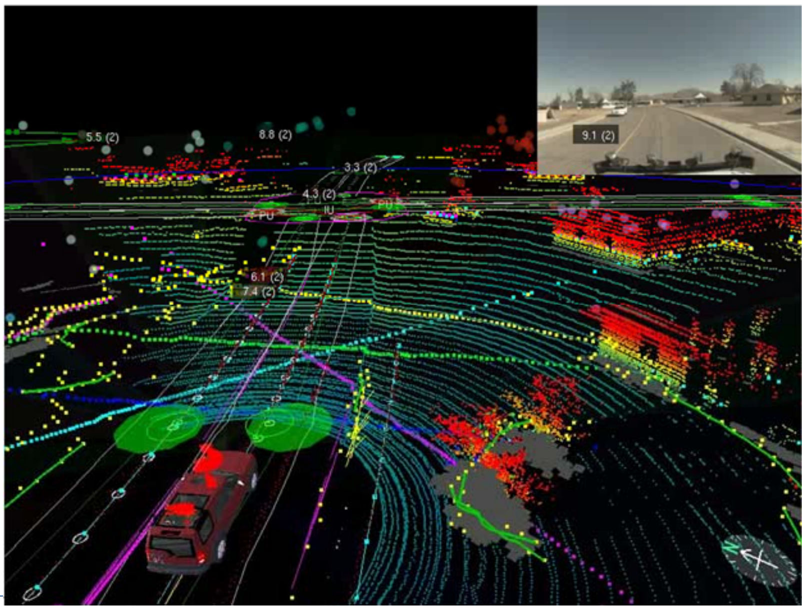
Edges, Segments, Colour, Texture

3D Stereo Vision



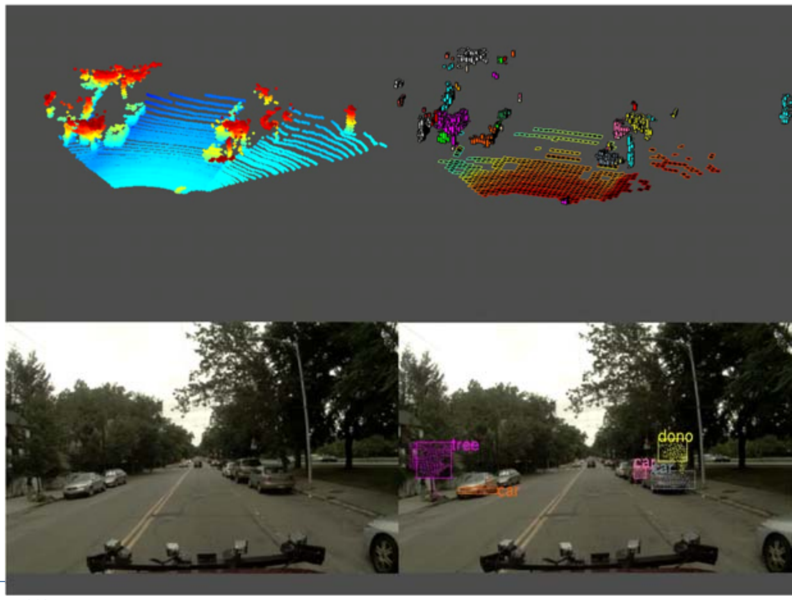


Laser Sensors

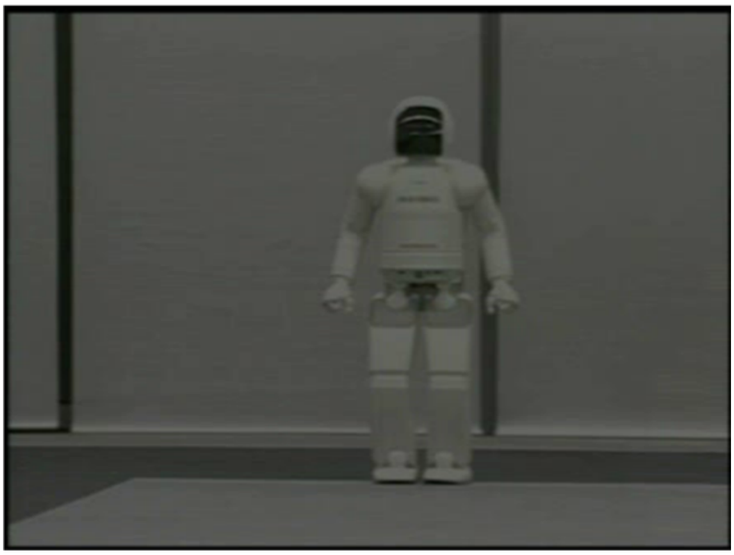


Processing …

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: Exploiting the hidden structure…

- Robot working in an "unstructured" environment

➔ Does not have to be dirty to use "field robotics" technology …

➔ Robotics is about exploiting the **structure** …

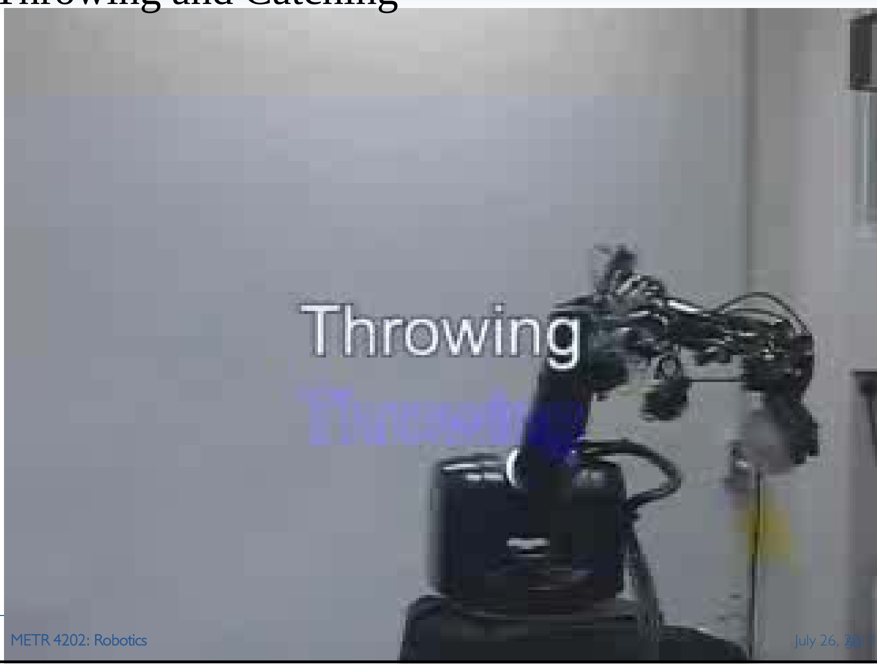
Either by:

- Putting it in from the design (mechanical structure)
- "Learning" it as the system progresses (structure is the data!)

Extending Our Reach…

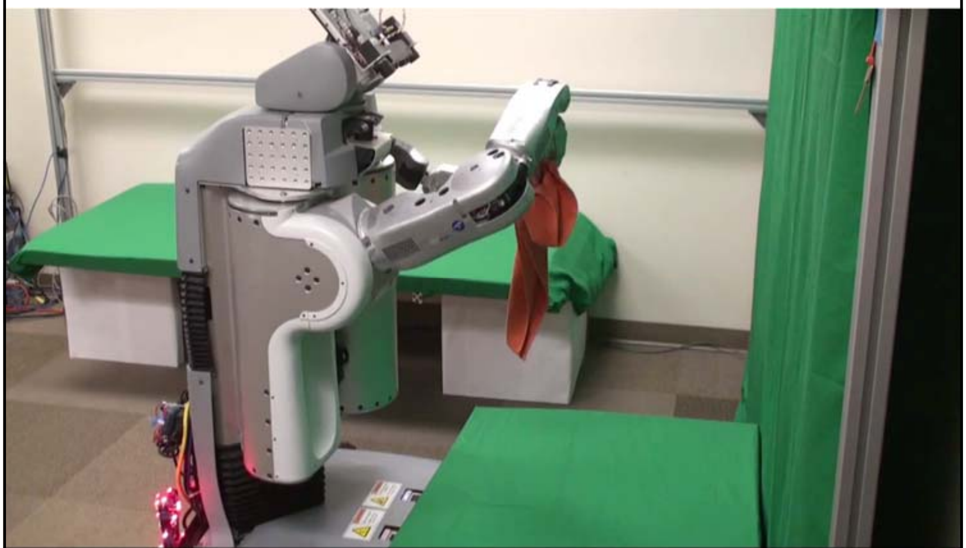
(what's hard is not what you expect…)

Throwing and Catching



Making Iced Tea

Shirt-Folding (30x speed up)…

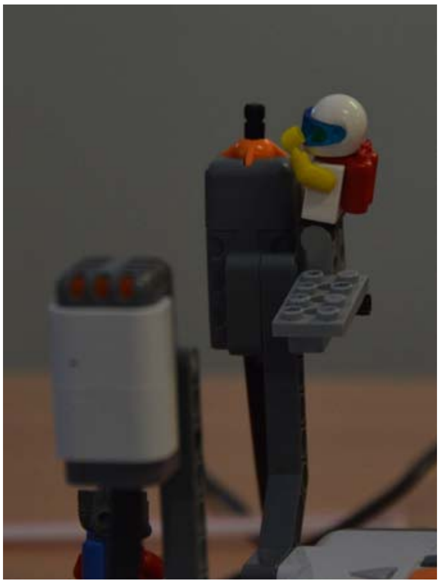


Shirt-Folding (1/3 Speed!)

Parallel-Parking…

Parallel Parking…

The Project!



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

This week's Tutorial …

- **NOT being held this week**
  (but you know this as
  the tutorials are on Wednesday
  & Lectures are on Friday!)