Robotics – COMP47130

Dr. Mauro Dragone

CLARITY Centre for Sensor Web Technology
School of Computer Science and Informatics
University College Dublin (UCD)
mauro.dragone@ucd.ie

Contacts

- **Email: Mauro.dragone@ucd.ie**
  - Optimal way to contact me, **use COMP47130 in subject**
- **T.A.: David Swords**

  (Email: david.swords@ucdconnect.ie)
- **Anara Sandygulova**

  (Email: Anara.Sandygulova@ucdconnect.ie)
- **CSI moodle http://csimoodle.ucd.ie/moodle/**
  - Announcements
  - Discussion group
  - Notes posted

Service Robotics

ISO 8373:2012 Robots and robotic devices – Vocabulary

A robot is an *actuated mechanism programmable* in two or more axes with a *degree of autonomy, moving within its environment*, to *perform intended tasks*.
A degree of autonomy" ranges from partial autonomy (including human robot interaction) to full autonomy (without active human robot intervention).

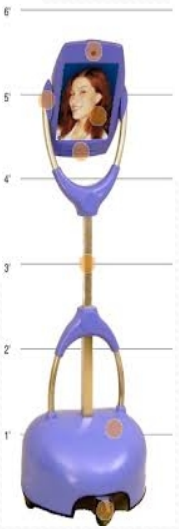
A service robot is a robot that performs useful tasks for humans or equipment *excluding industrial automation application*.

A personal service robot or a service robot for *personal use* is a service robot used for a *non-commercial task*, usually by *lay persons*. Examples are domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.

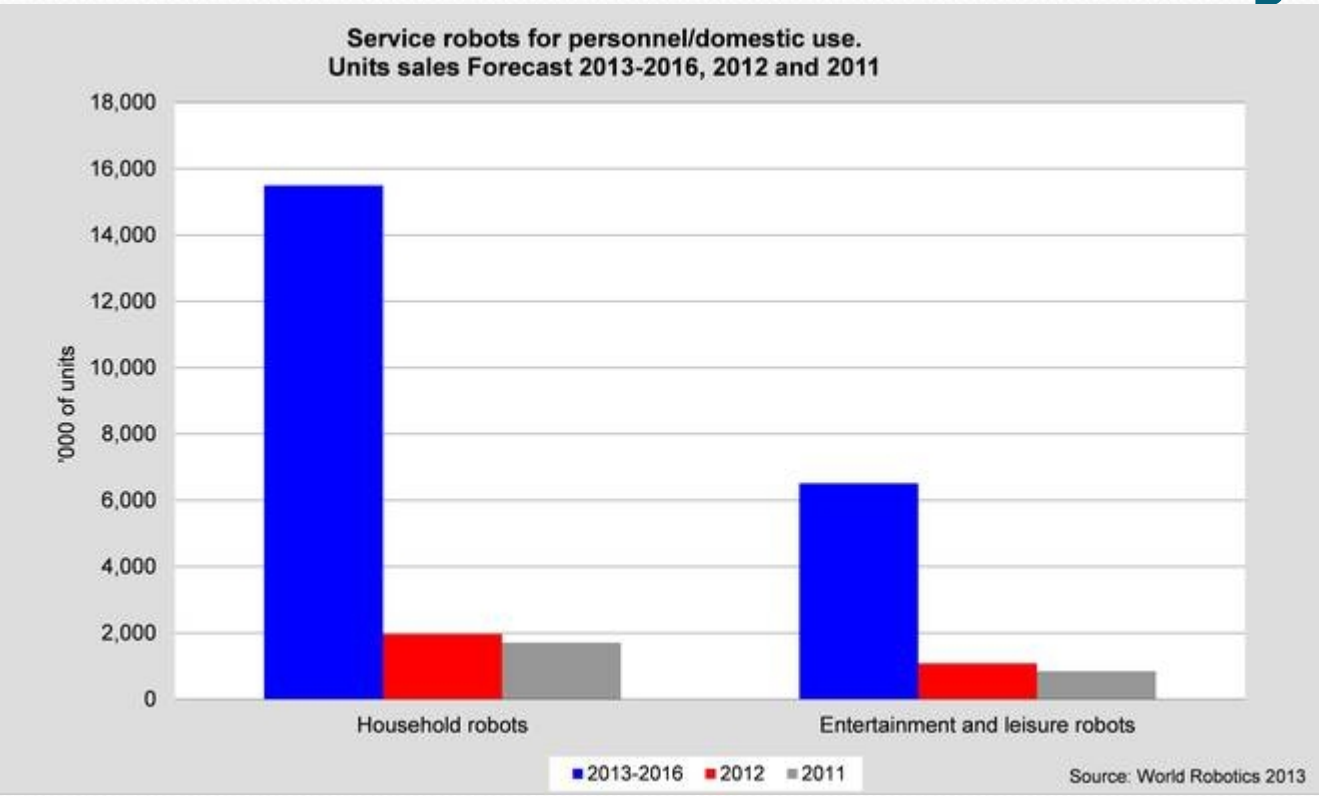
A professional service robot or a service robot for professional use is a service robot used for a commercial task, usually operated by a properly trained operator. Examples are cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot and surgery robot in hospitals. In this context an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system.

Source: International Federation Robotics (IFR, see http://www.ifr.org/service-robots/)

Service Robotics



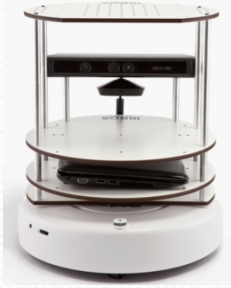
Service Robotics Today



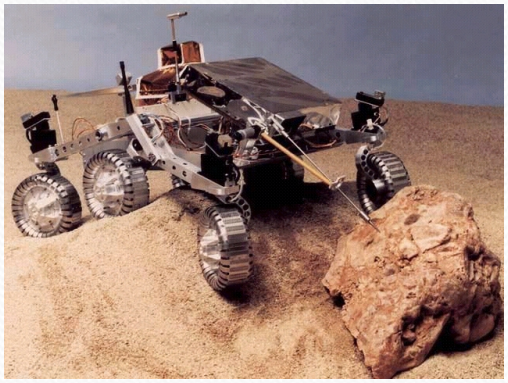
According to the World Robotics Survey published by the International Federation Robotics (IFR, see http://www.ifr.org/service-robots/), in 2012, about 3M service robots for personal and domestic use were sold, 20% more than in 2011. The value of sales increased to US$1.2 billion. **Projections for the period 2013-2016**: About 100K new service robots for professional use, 22M units for personal use, 3.5M toy/hobby units, 3M units for education and research, 6.400 units for elderly and handicap assistance. This market will increase substantially within the next 20 years.

Other examples of Robot Technologies

iRobot



TurtleBot



JPL Mars Rover

Snake Robot

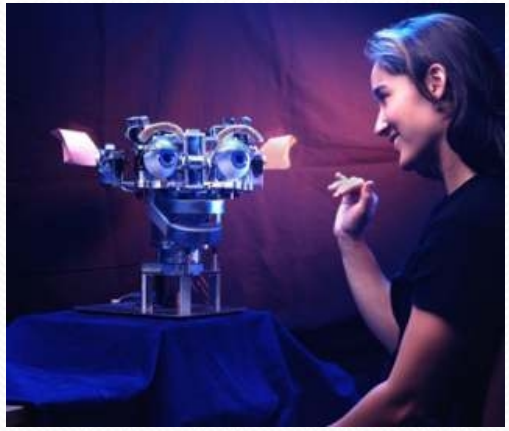
Google Car

HONDA Asimov

Nao

Other examples of Robot Technologies

NEC PaPeRo



Kismet [MIT]

CompanionAble

TOYS/
Education

Android Clone
[Osaka University]

RoboCup

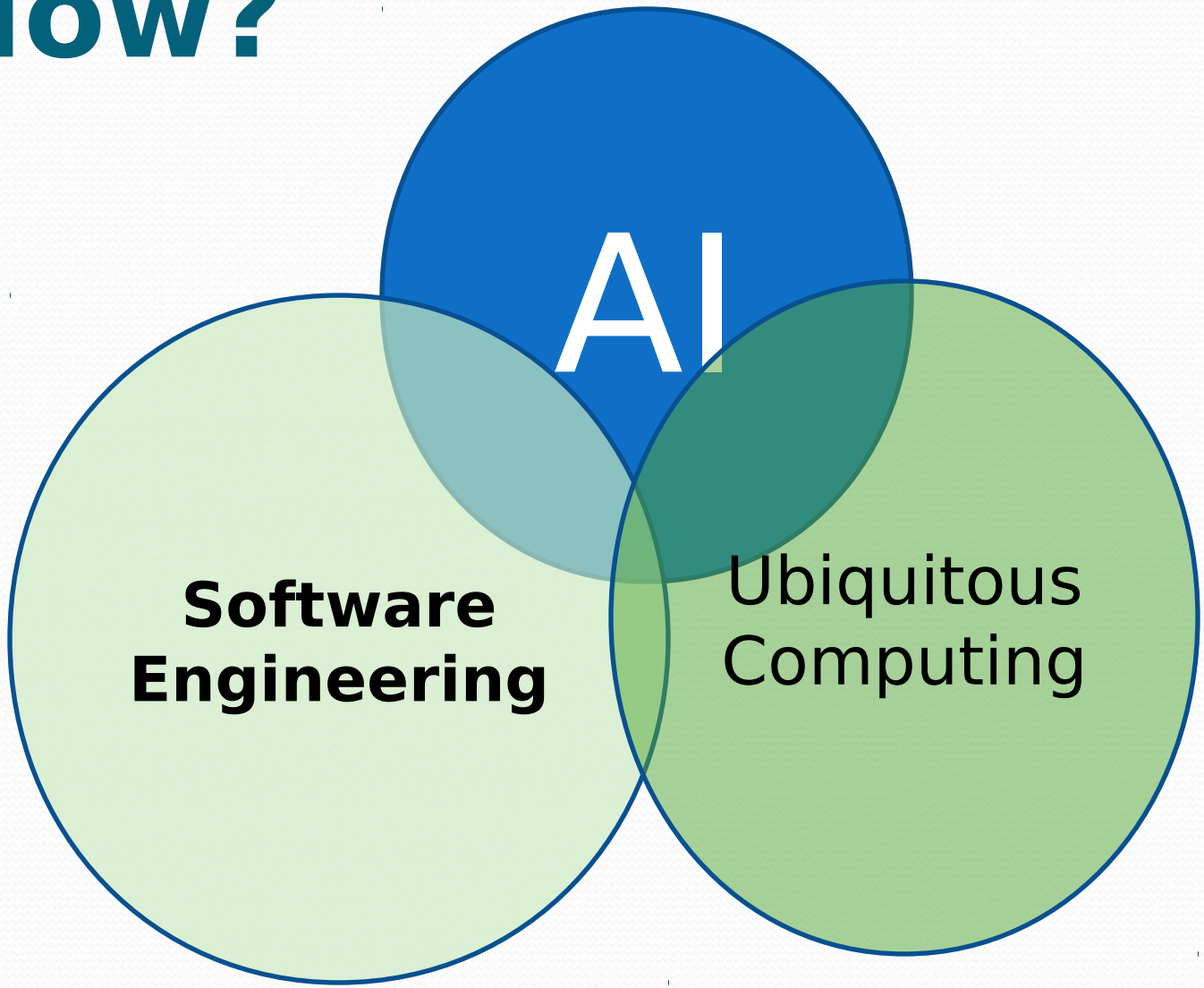
Robotic Ecologies

Many specialized, pervasive “robotic” devices

- Moving tables, cameras, manipulators, appliances, wireless sensors nodes...

  => Complex abilities achieved through cooperation
- Intrinsically modular and expandable (just add new devices...)
- Extend the type of application that can be realistically envisaged
- Reduce the complexity of the overall system
- Enhance the value of the services delivered by each device

How?



COMP47130 Autonomous Robotic Systems

Outcome

- Understand current and future-looking trends in robotics
- Have an up-to-date knowledge of important robotics software and simulation systems.
- Core advanced programming skills in specific areas of robotics (e.g. autonomous navigation, localization, object tracking, ...).
- Engage with primary literature within robotics .
- Appreciate the theoretical underpinnings (e.g. styles of control architecture, sensory-motor behaviours...)
- Critically assess theory and applications in the area.

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Indicative Readings

Papers will be posted on csimoodle

Other readings:

Books:

Probabilistic Robotics by Thrun, Burgard & Fox

Course Content

- **Practical component is extremely challenging**
  - Do not underestimate it!
  - Design, Programming, Experiments
  - **Programming Experience is required!**

- **We will use:**
  - **C, C++, (Java), Linux**
  - **Robotic Operating System (ROS)**
  - **Stage/Gazebo Robot Simulator for development**
  - **Validation with Real Robots**

COMP47130 Autonomous Robotic Systems

Content

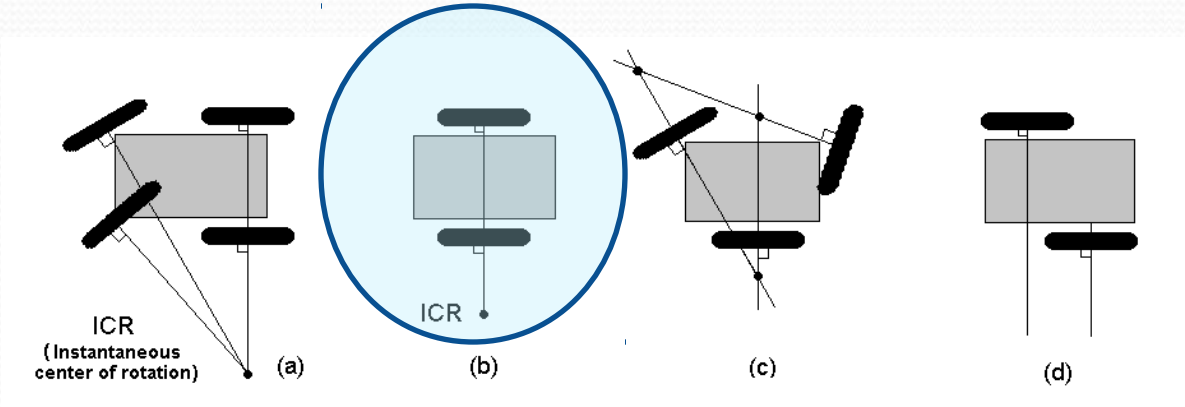
This module will provide key theoretical foundations underpinning robots' autonomous operations, **embracing both AI and Software Engineering aspects**. These foundations will be grounded through an **hands-on** and project based approach to learning. Students will **practice** with advanced robotics hardware as well as **open source software**, simulators and problem sets used within the robotics community.

Topics covered:

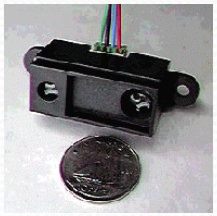
- sensors and actuators
- single and multi-robot control architectures
- robots' perception and behaviours
- obstacle avoidance and navigation
- localization and mapping
- object tracking / machine vision
- human-robot interaction

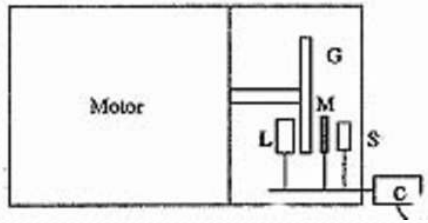
COMP47130 Autonomous Robotic Systems

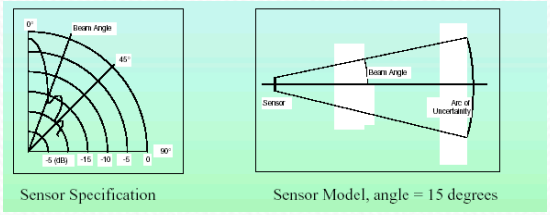
Sensors & Actuators



Wheeled Mobile Robots
Differential Driving System







Robotic Sensors (operations, models, software...)

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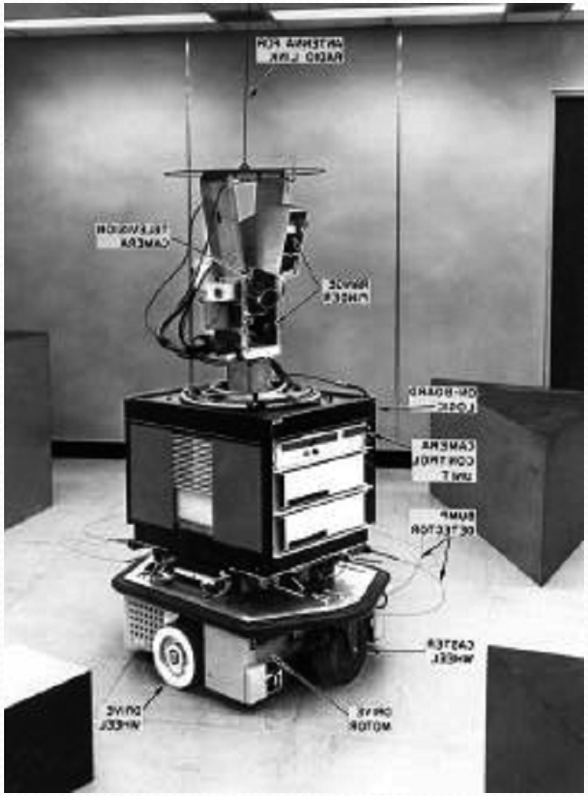
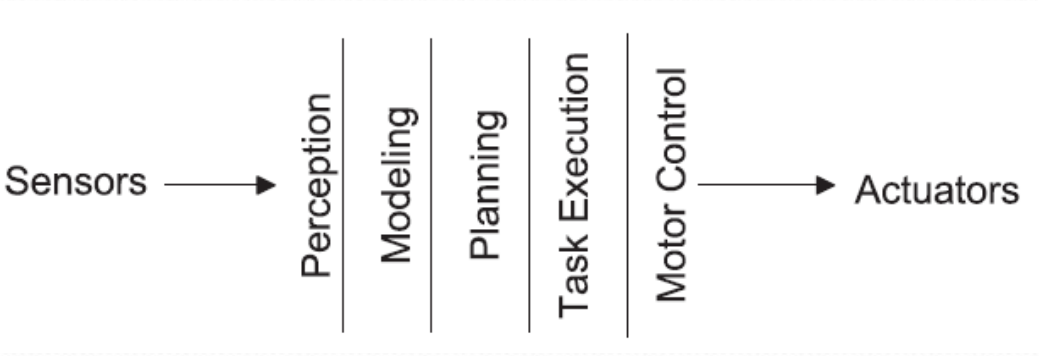
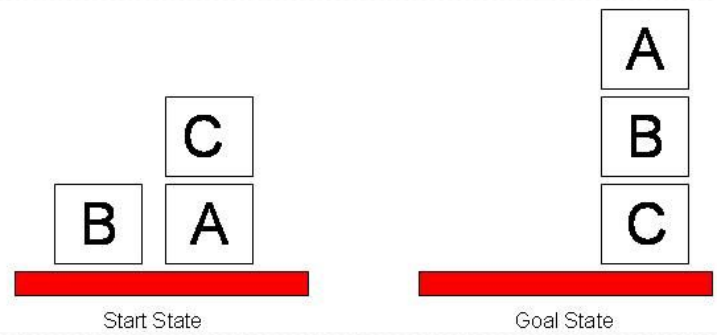
Robot Architectures: Sense, Plan, Act







Top-Down Approach

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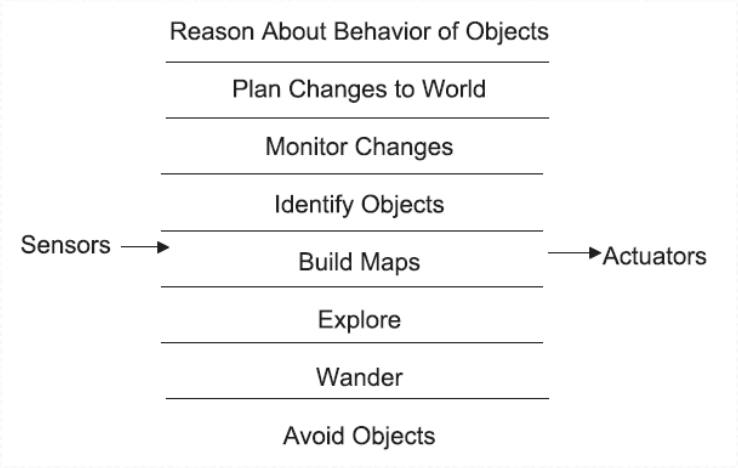
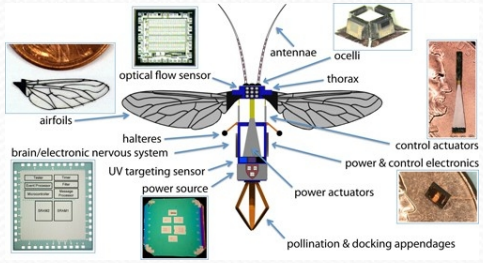
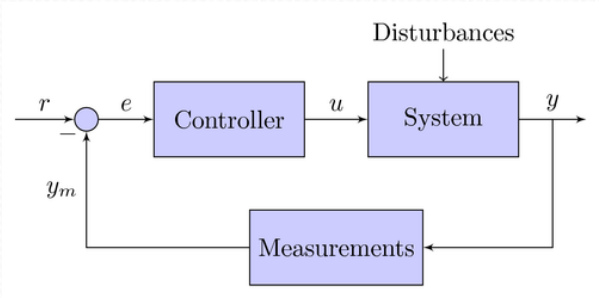
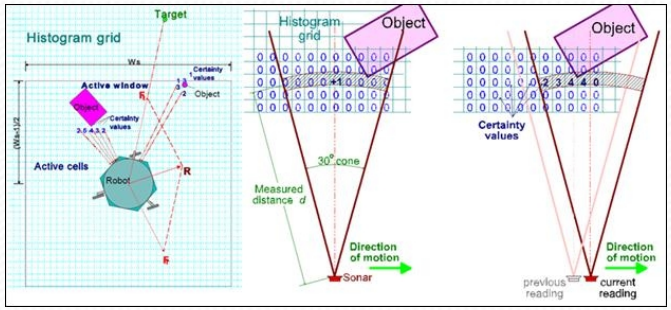
Robot Architectures: Behaviour-Based



Principles & Examples

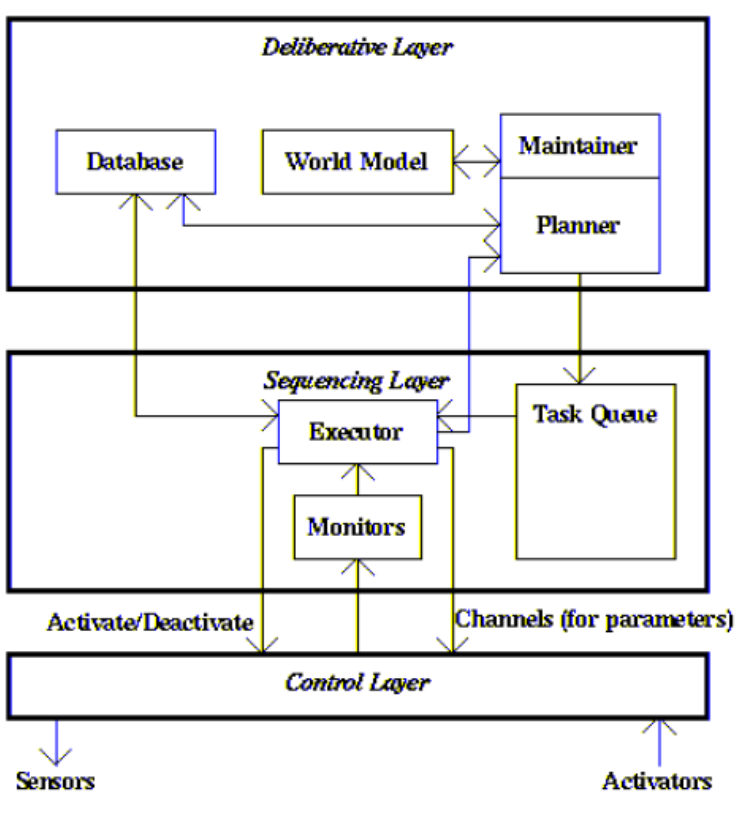






- Bottom-Up Approach
- Embodiment
- Biological Inspiration
- Emergent Behaviour
- Stigmergy

Robot Architectures: Hybrid Architectures

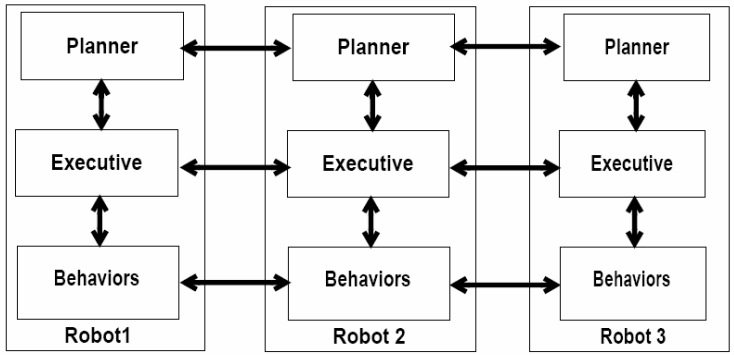


Advancement in Planning

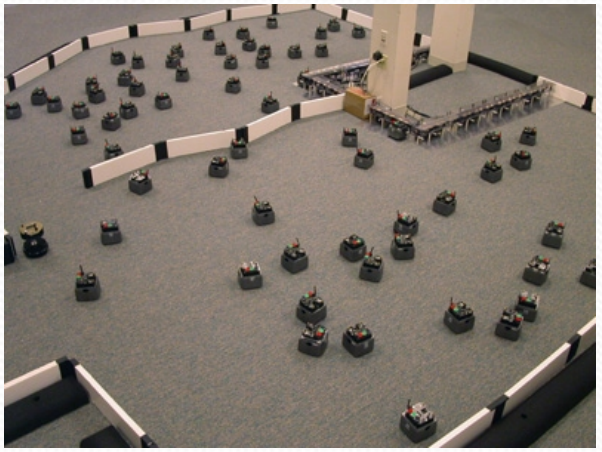
Advancement in Sensors and Perception

Connection between symbolic & sub-symbolic layers
- Symbol Anchoring

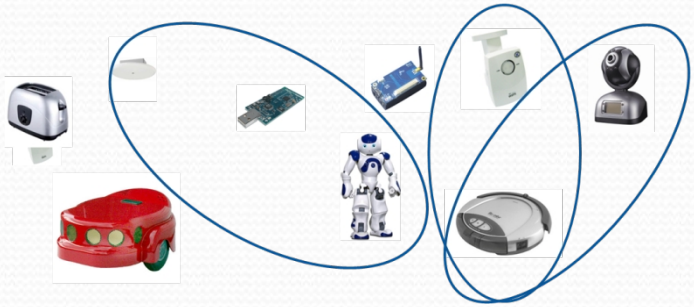
Multi-Robot Systems



Multi-Agent Approach



Swarm Robotics



Robotic Ecologies

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(Intro) Localization

Probabilistic Filters
- Kalman Filter
- Particle Filter
- Localization
- Simultaneous Localization and Mapping (SLAM)

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(Intro) Machine Vision

Applications
- Object Tracking
- Obstacle Avoidance

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(Intro) Human Robot Interaction

Degrees of Autonomy
- Direct Control
- Supervisory Control
- Mixed Initiative

Social Robotics

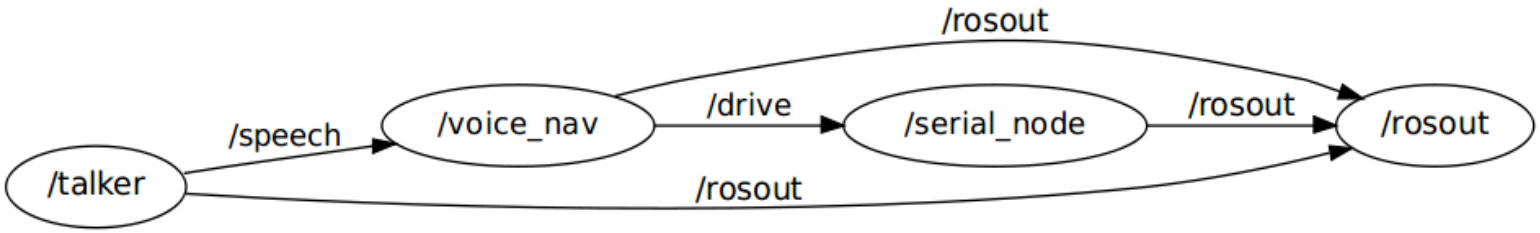
In this class

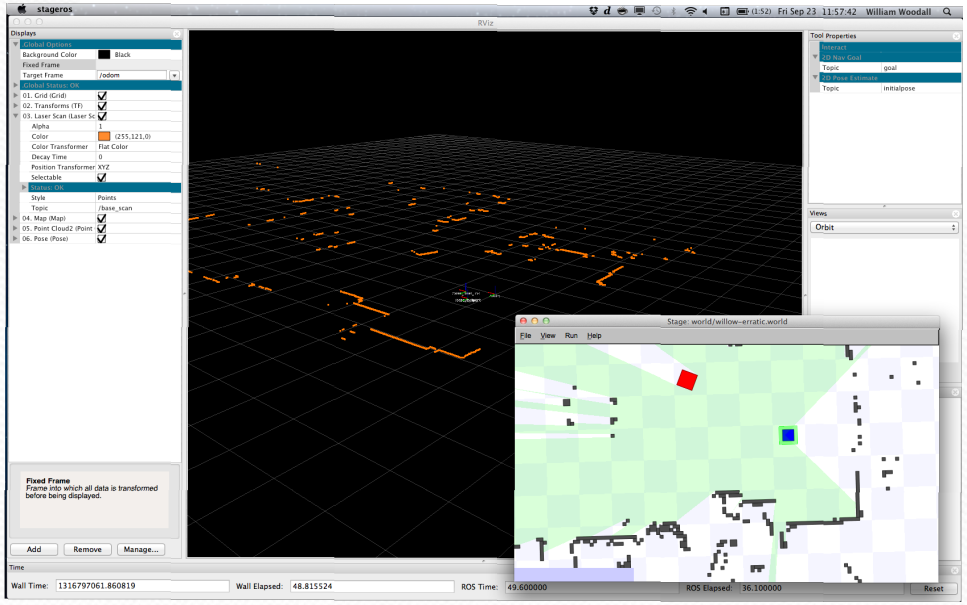
- **Practicals (70%):**
  - **Programming Assignment (30%)**
  - **Project (and test) (40%)**

  Evaluation based on quality of software, AND performance

- **Research Essay (Survey Paper / Presentation) (30%)**

ROS – Robotic Operating System





Stage simulator

Component-based, modular programming style

System is distributed across software nodes interacting by messages and services

Ingredients

- **2 hours lectures a week**
- **1 lab slot @ 2 hours**

  But you'll need more
- **Readings & tutorials**
- **Support from me, the T.A. and the demonstrator(s), your peers, ROS forum ...**