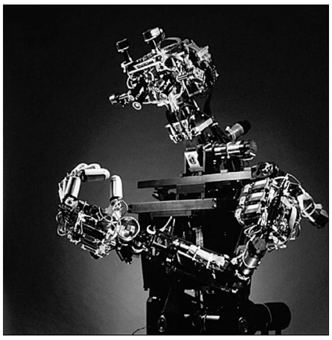
COMP4411: Experimental Robotics



People in COMP4411

- Lecturers
  - Claude Sammut (lecturer-in-charge)
    - claude@cse.unsw.edu.au
  - Maurice Pagnucco (lecturer)
    - morri@cse.unsw.edu.au
- Technical Support
  - John Zaitseff
    - zaitseff@cse.unsw.edu.au

Lectures

- 2 - 5pm Tuesdays
- Week 1
  - 2 - 4pm: K17 level 1 Seminar Room;
  - 4 - 5pm: Level 3 Robotics Lab
- Weeks 2 - 12
  - Level 3 Robotics Lab
- Swipe card access to Level 3 will be arranged in the next week

Session Schedule

- Week 1 - course introduction, lab tour
- Weeks 2-4 - all students use Player/Stage (playerstage.sourceforge.net) to complete a simple navigation task
- Week 2/3 - project registration
- Weeks 2 - 12 - project development, with weekly meeting and milestones
- Week 5 - mid session mini-demonstration
- Week 12 - Presentation and Demo, technical report handed in

Assessment

- Player/Stage navigation task 5%
- Mid-session demonstration 10%
- Final Demonstration 45%
- Accompanying Report 40%
- To pass COMP4411 you must pass ALL components

Occupational Health and Safety

- Computer Ergonomics for Students
  - http://do.cse.unsw.edu.au/ergonomics/ergoadjust.html
- OHS Responsibility and accountability for students
  - http://do.cse.unsw.edu.au/ergonomics/ohs.html

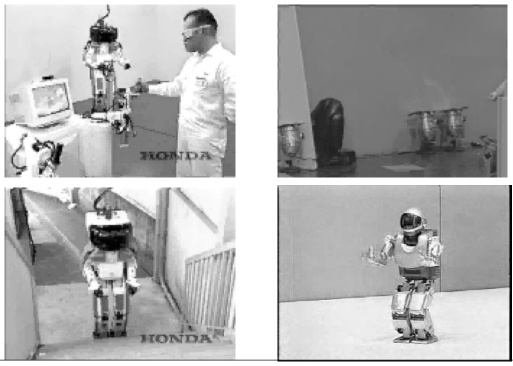
Undergraduate Study in AI

- COMP3411: Artificial Intelligence
- COMP3431: Robot Architectures
- COMP4411: Experimental Robotics
- COMP4412: Introduction to Modal Logic
- COMP4415: Logical Foundations of Artificial Intelligence
- COMP4416: Intelligent Agents
- COMP4417: Machine Learning
- COMP4418: Knowledge Rep. & Reasoning

Postgraduate Study in AI

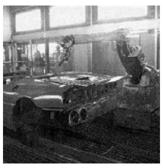
- COMP9414: Artificial Intelligence
- COMP9417: Machine Learning
- COMP9444: Neural Networks
- COMP9517: Computer Vision

Humanoid Robots



Industrial Robots

Industrial Robots are ...



- Deaf
- Dumb
- Blind
- … and stupid!

What is Robotics?

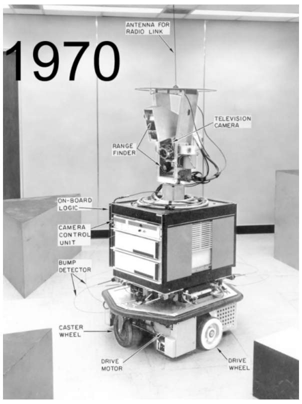
"Robotics is the intelligent connection of perception to action"

– Mike Brady, Oxford University

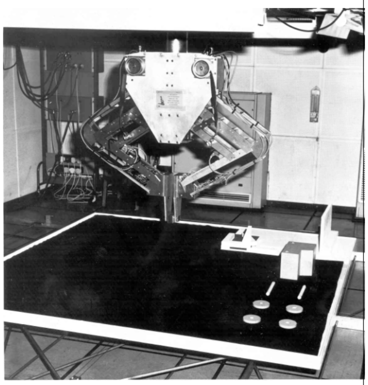
Intelligent Robots

- Must perceive environment
  - cameras, rangefinders, sound, touch, smell
- Recognise objects
  - Vision, speech recognition, etc
- Form a representation of the world
  - Knowledge representation
- Plan and execute actions
  - Planning and theorem proving
- Cooperate with other agents
  - communication

Shakey (SRI)

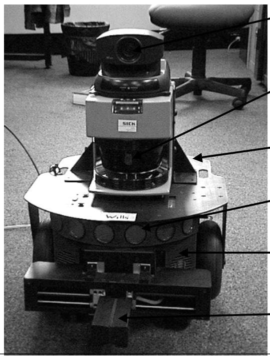


Freddy (Edinburgh)

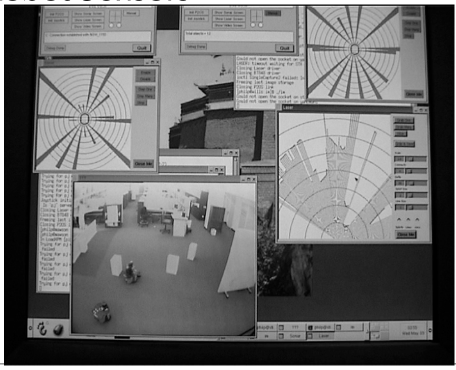


Mobile Robots

Pioneer II



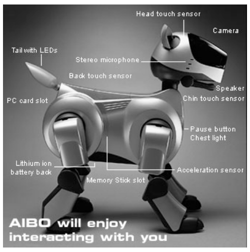
Robot Sensors

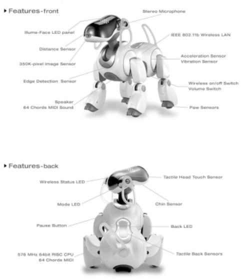


Pioneer 3

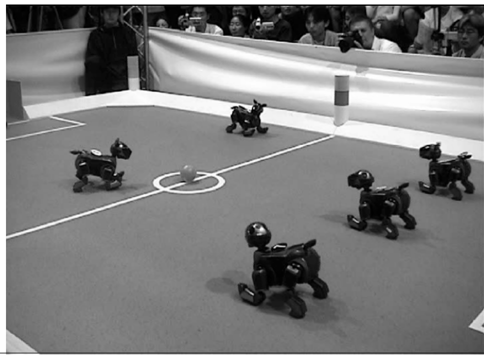
PeopleBot

SONY AIBO



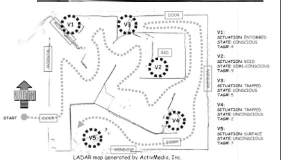


RoboCup



RoboCup Rescue

- Goal
  - Map disaster site
  - Locate survivors
- Environment
  - Unstructured
  - Hazardous
- Application of
  - Perception
  - Mapping & Localisation
  - Learning



Research

- Sensing
  - LADAR, SONAR, GPS, VISION, IR, IMU, Gas sensors
- 3D SLAM
- Locomotion
  - Wheels, Legs, Tracks, UAV, snake
- Heterogeneous Multi-agent co-ordination
- Full automation
- Learning

Test Arenas

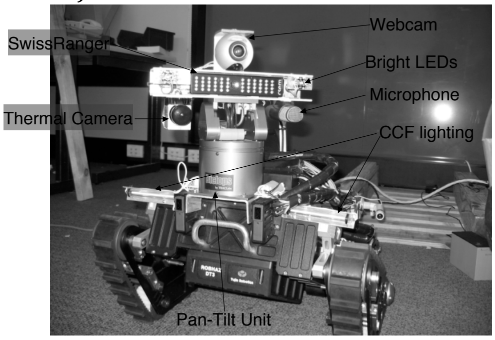
Search and Rescue

Victim Identification

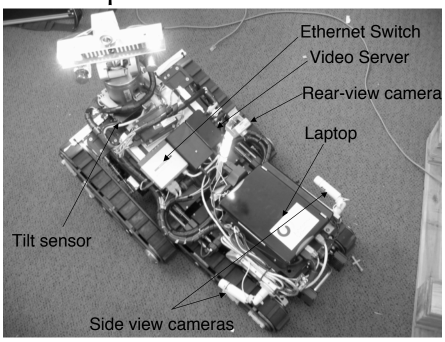
Autonomous vs Tele-operated

- Initially Yellow arena autonomous (UTS)
- Orange and Red tele-operated (UNSW)
- Migrate autonomy work to tele-operation to lighten burden on operator
- User-interface from tele-operation migrates to autonomous operation for human-machine cooperation

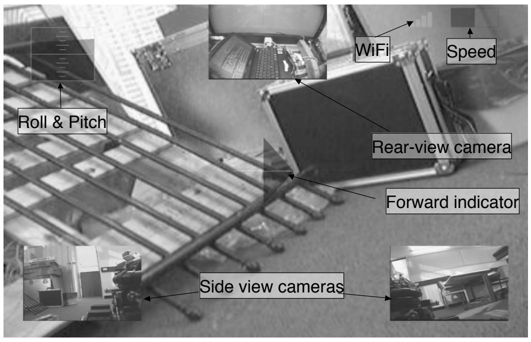
Yujin Robotics RobHaz DT3++



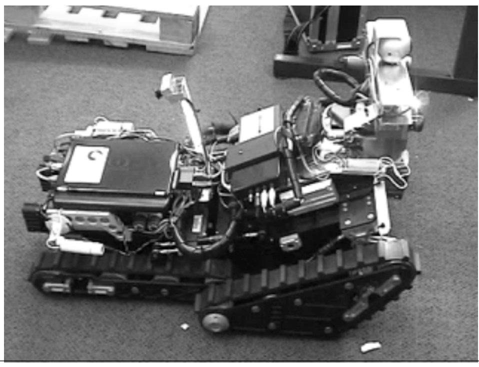
DT3 Top View



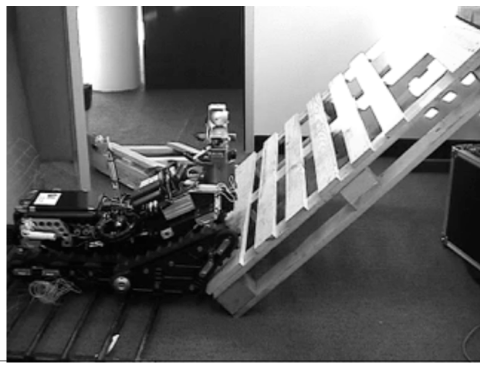
User Interface



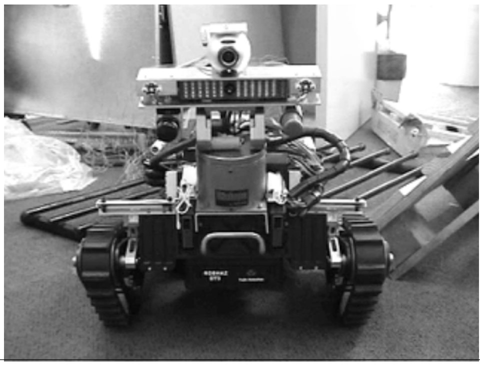
DT3 Test Run



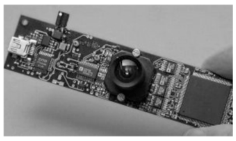
DT3 Test Run

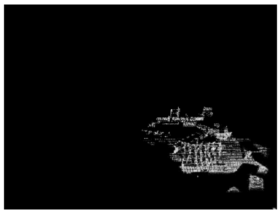


3D SLAM scan

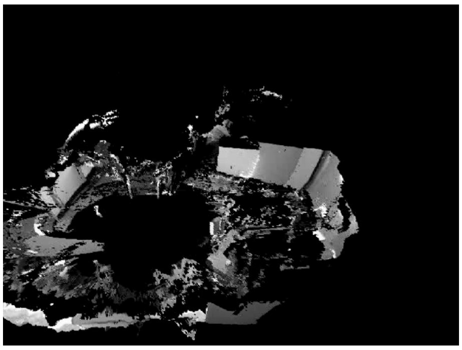


SLAM with 3D Camera

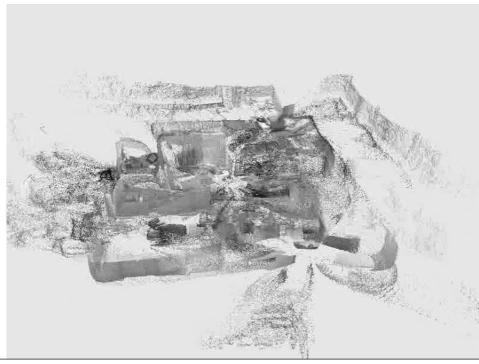




3D Reconstruction

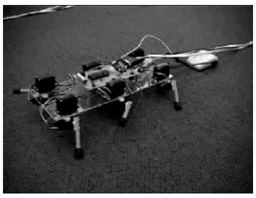


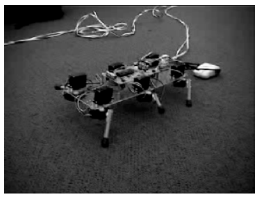
3D Reconstruction



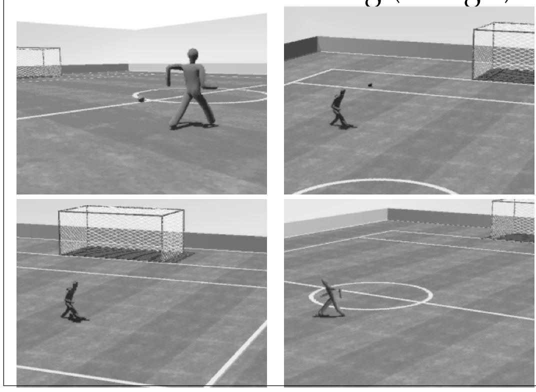
Thermal Camera

Reinforcement Learning (Ryan)

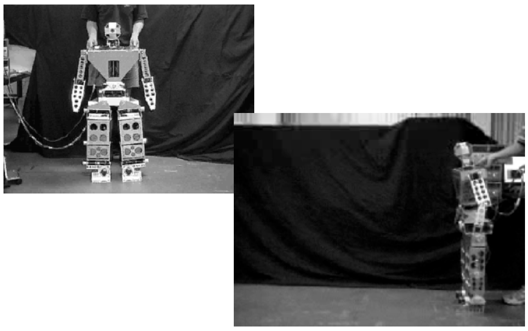




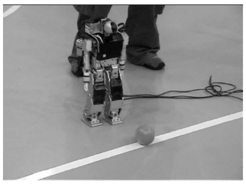
Reinforcement Learning (Hengst)

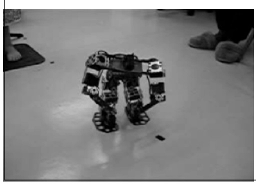


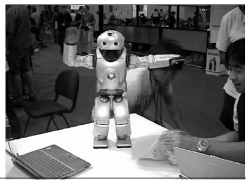
Evolutionary Learning (Yik)



Humanoid Robots

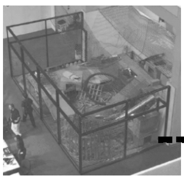






RoboCup Rescue

RoboCup Rescue



COMP4411 Project

- Projects based on RoboCup Rescue theme
- Each project tackled by a group of 3-4 students
- Projects must be confirmed by Week 3 at the latest
- Mid-session presentation - Week 5
- Final presentation and Demo - Week 12

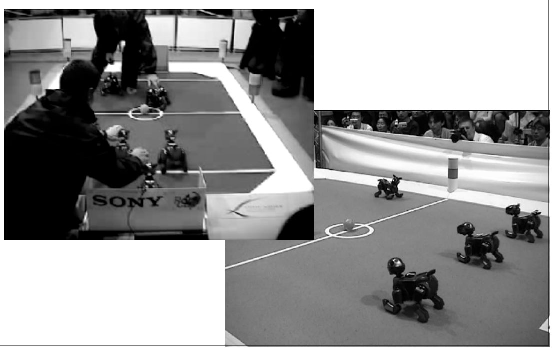
Homework

- Look at the following material
  - Player/Stage (http://playerstage.sourceforge.net)
  - RoboCup@Home (http://www.robocupathome.org)
  - RoboCup Rescue (http://robomec.cs.kobe-u.ac.jp/robocup-rescue)

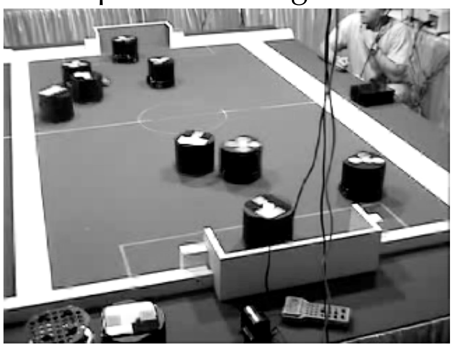
COMP4411: Experimental Robotics

Case Study: Robot Soccer

RoboCup - Legged League



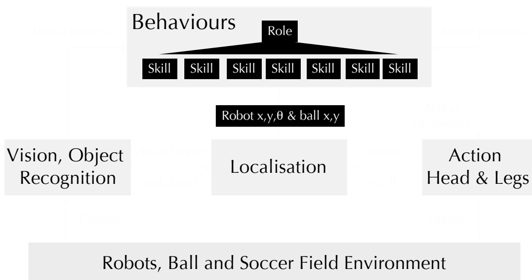
RoboCup - Small League



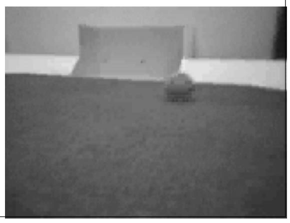
Why make robots play soccer?

- Robots must perceive environment
- Recognise objects
- Form a representation of the world
- Plan and execute actions
- Cooperate with team mates
- Operate in a hostile environment

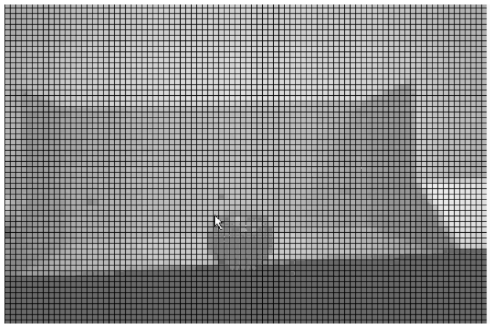
Architecture



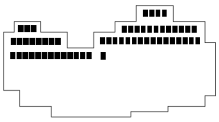
Robot Vision



Training robots to see colours



Blob formation



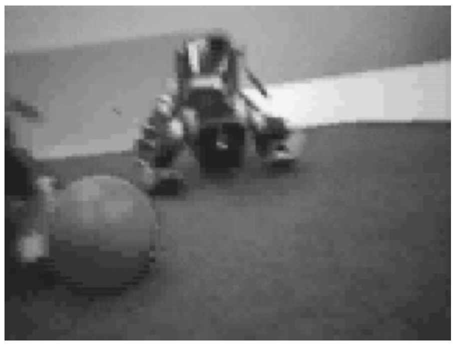
- Once pixels are labelled, a blob forming algorithm groups related pixels into regions
- Blob formation is a 2D operation
- Blobs have properties
  - Bounding box, centroid, moments of inertia
- Regions are then identified with objects

Object Recognition

Other Vision Primitives

- Edge detection
- Line finding
- Shape from
  - Shading
  - Contours
- 3D from
  - stereo
  - Range maps
- Motion
  - Detection
  - Recognition

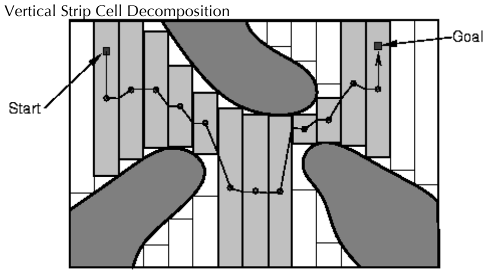
Doggie Cam



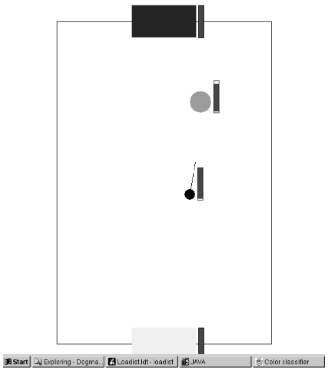
What the robot sees

Navigation and Motion Planning

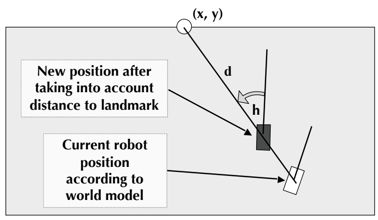
Vertical Strip Cell Decomposition



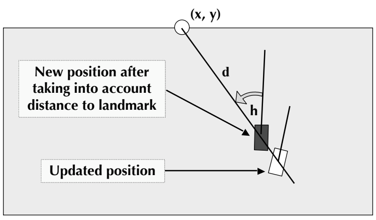
World Model



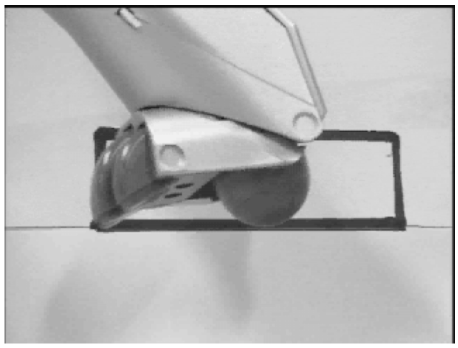
Localisation



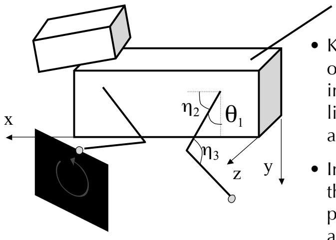
Localisation



Locomotion

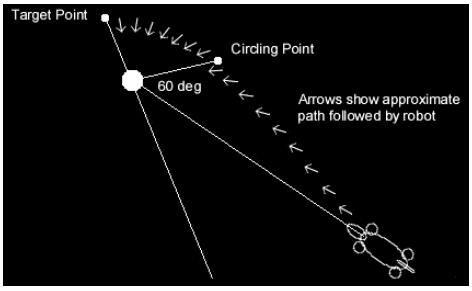


Inverse Kinematics

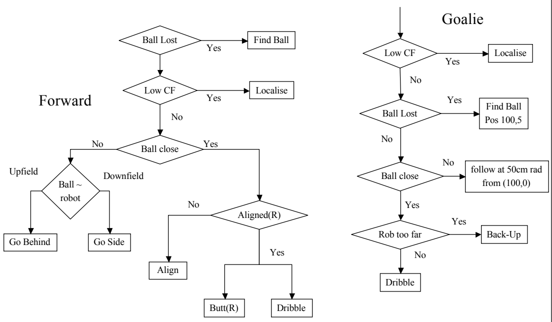


- Kinematics is the process of calculating the position in space of the end of a linked structure, given the angles of all the joints.
- Inverse Kinematics does the reverse. Given the end point of the structure, what angles do the joints need to be in to achieve that end point.

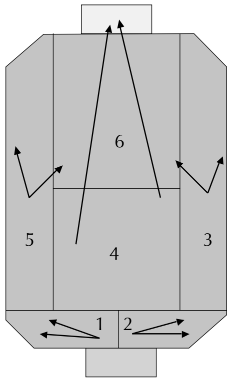
Circling Behaviour



Conan Strategy



Field Regions



Reactive vs Deliberative

- Reactive systems only have "situation-action" responses
- Deliberative systems plan behaviours
- Actions have:
  - Preconditions
    - Conditions that must be true before performing action
  - Add list
    - Conditions that become true after performing action
  - Delete list
    - Conditions that become false after performing action

Planning in STRIPS

- Actions have:
  - Preconditions
    - Conditions that must be true before performing action
  - Add list
    - Conditions that become true after performing action
  - Delete list
    - Conditions that become false after performing action

Planning by backward chaining

- What is my goal?
- If goal condition is true then stop
- Is there an action whose "add list" contains the goal?
- What are the action's preconditions?
- Make them my new sub-goals
- Perform action once all preconditions are satisfied