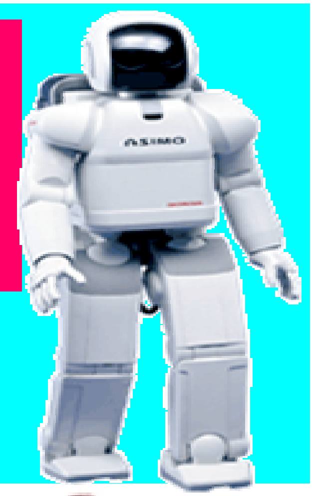
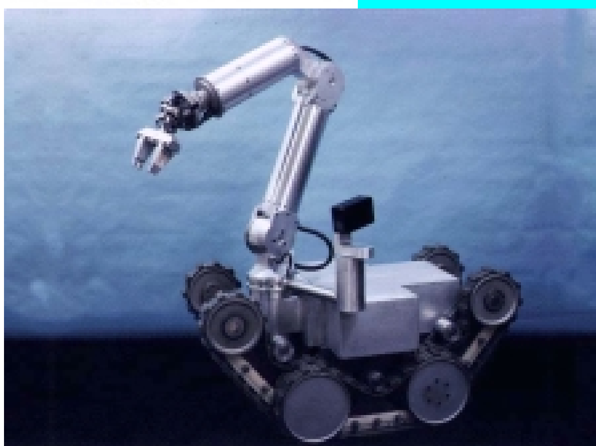
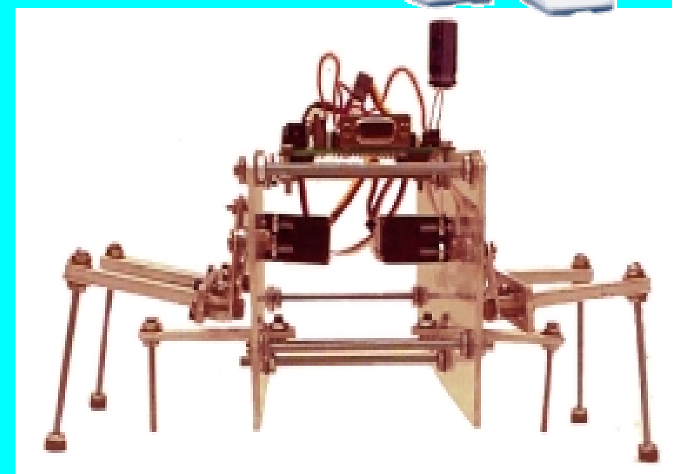
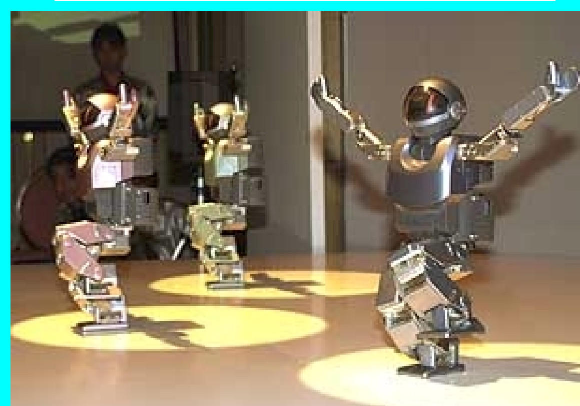
Introduction to Robotics




A255 robot







Vikram Kapila, Associate Professor, Mechanical Engineering

Outline

- Definition
- Types
- Uses
- History
- Key components
- Applications
- Future
- Robotics @ MPCRL

Robot Defined

- Word robot was coined by a Czech novelist Karel Capek in a 1920 play titled Rassum's Universal Robots (RUR)
- Robot in Czech is a word for worker or servant

Karel Capek

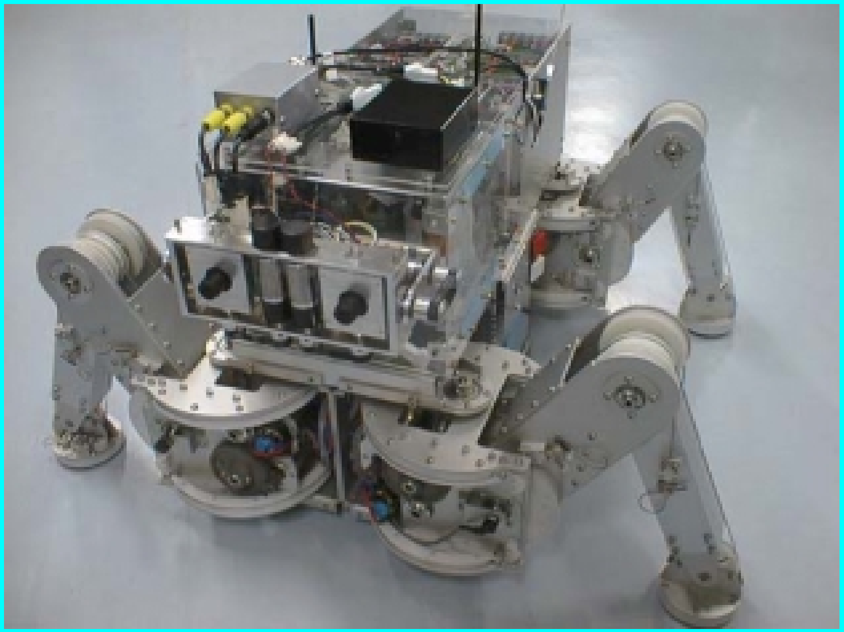
- Definition of robot:
  - –Any machine made by by one our members: Robot Institute of America ☺
  - –A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks: Robot Institute of America, 1979

Types of Robots: I

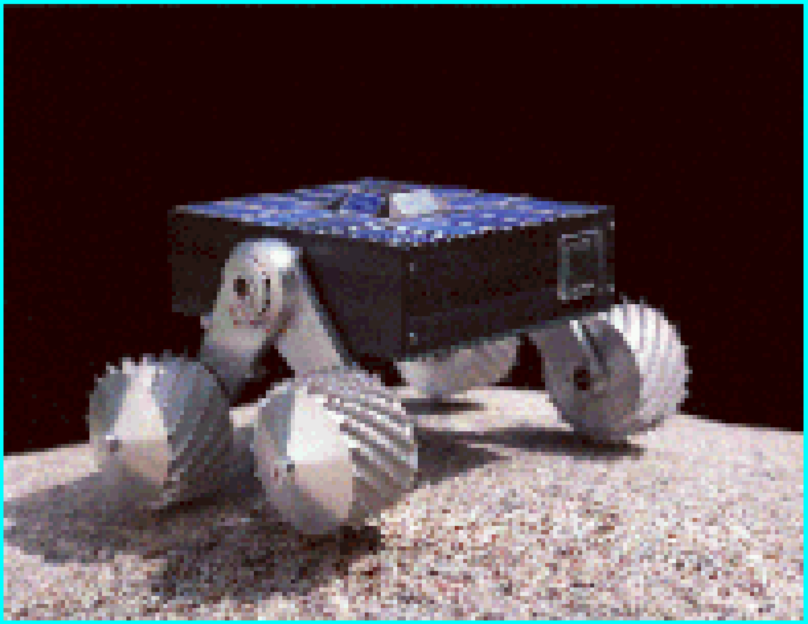
Manipulator

Types of Robots: II

Legged Robot



Wheeled Robot

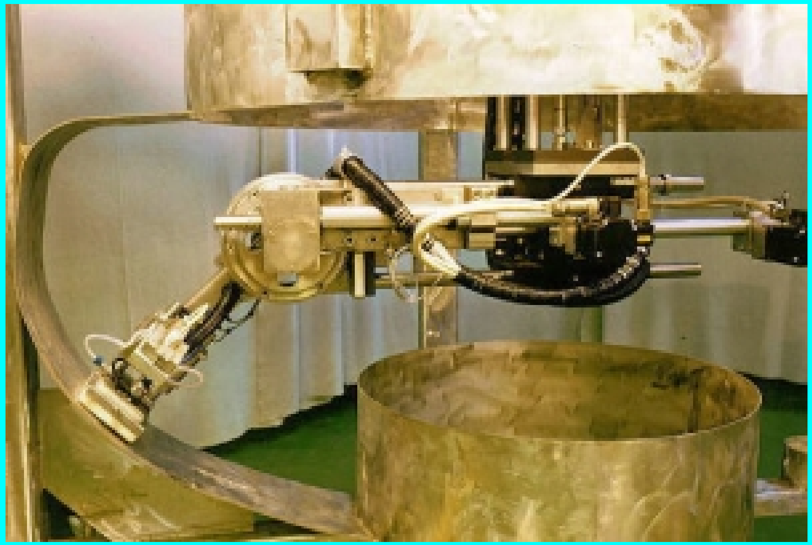


Types of Robots: III

Autonomous Underwater Vehicle

Unmanned Aerial Vehicle

Robot Uses: I

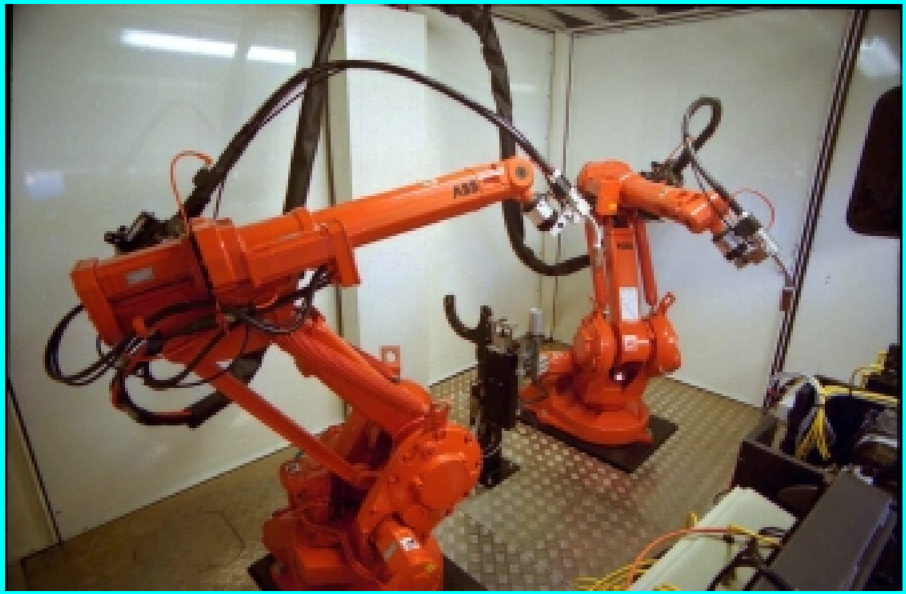


Jobs that are dangerous for humans

Decontaminating Robot

Cleaning the main circulating pump housing in the nuclear power plant

Robot Uses: II



Welding Robot

Repetitive jobs that are boring, stressful, or labor-intensive for humans

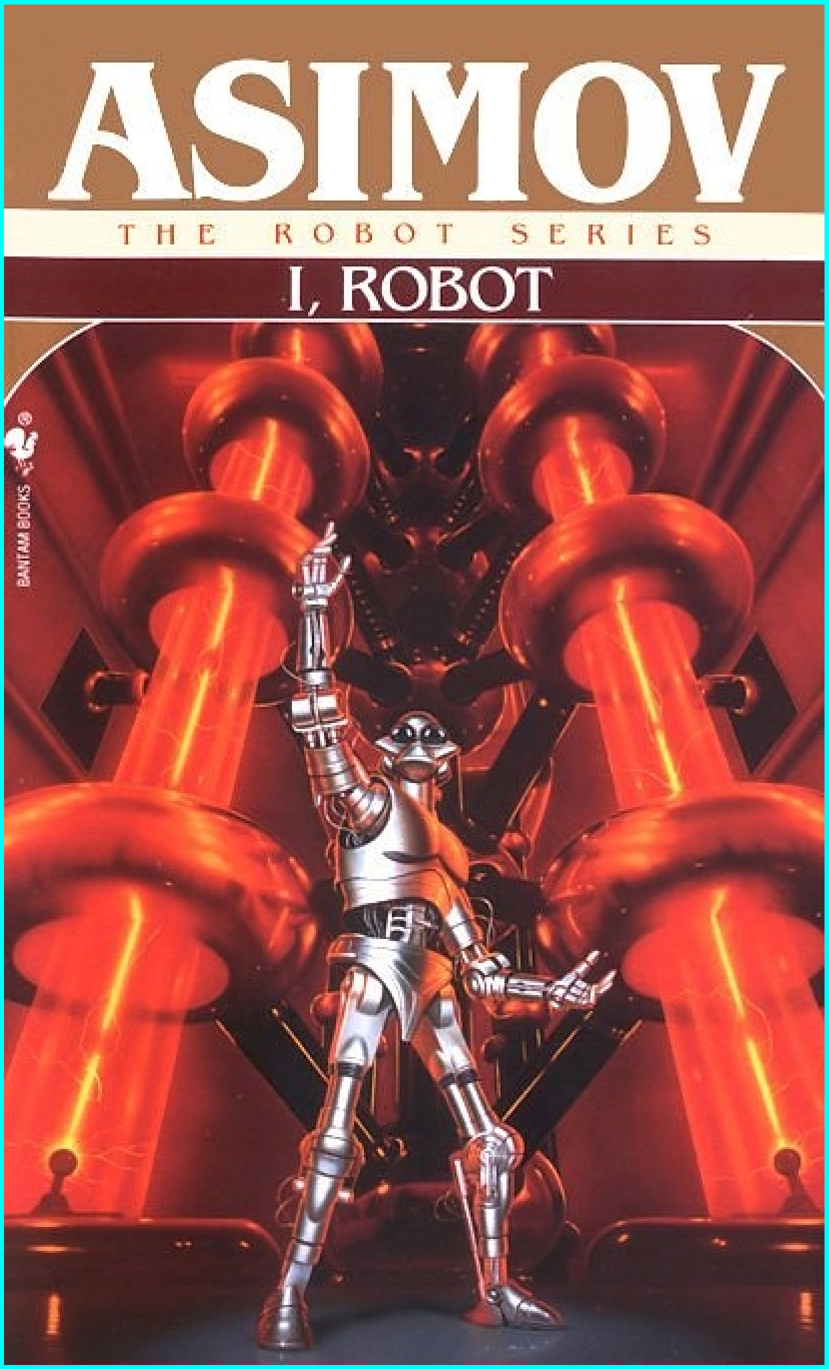
Robot Uses: III

The SCRUBMATE Robot

Menial tasks that human don’t want to do

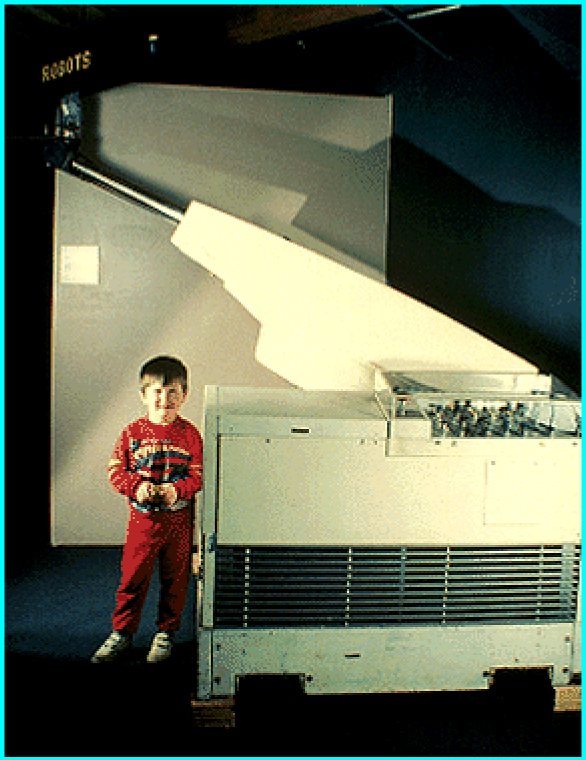
Laws of Robotics

- Asimov proposed three "Laws of Robotics" and later added the "zeroth law"
- Law 0: A robot may not injure humanity or through inaction, allow humanity to come to harm
- Law 1: A robot may not injure a human being or through inaction, allow a human being to come to harm, unless this would violate a higher order law
- Law 2: A robot must obey orders given to it by human beings, except where such orders would conflict with a higher order law
- Law 3: A robot must protect its own existence as long as such protection does not conflict with a higher order law



History of Robotics: I

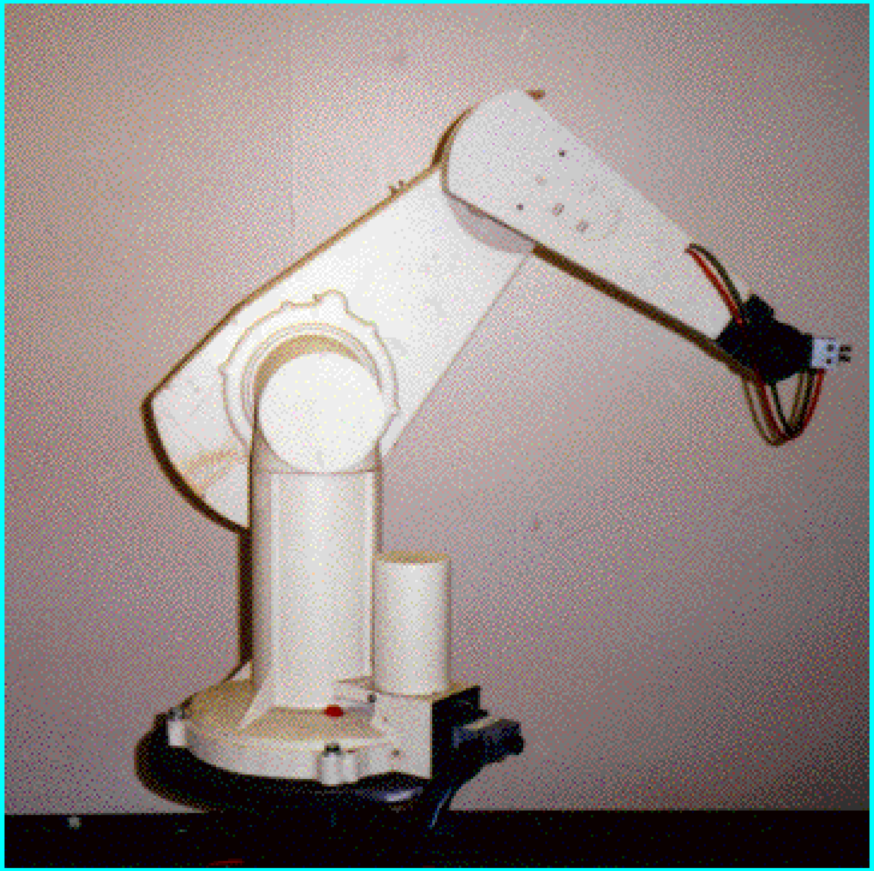
- **The first industrial robot: UNIMATE**
- 1954: The first programmable robot is designed by George Devol, who coins the term Universal Automation. He later shortens this to Unimation, which becomes the name of the first robot company (1962).



UNIMATE originally automated the manufacture of TV picture tubes

History of Robotics: II

1978: The Puma (Programmable Universal Machine for Assembly) robot is developed by Unimation with a General Motors design support



PUMA 560 Manipulator

History of Robotics: III

1980s: The robot industry enters a phase of rapid growth. Many institutions introduce programs and courses in robotics. Robotics courses are spread across mechanical engineering, electrical engineering, and computer science departments.

Adept's SCARA robots

Cognex In-Sight Robot

Barrett Technology Manipulator

History of Robotics: IV

1995-present: Emerging applications in small robotics and mobile robots drive a second growth of start-up companies and research

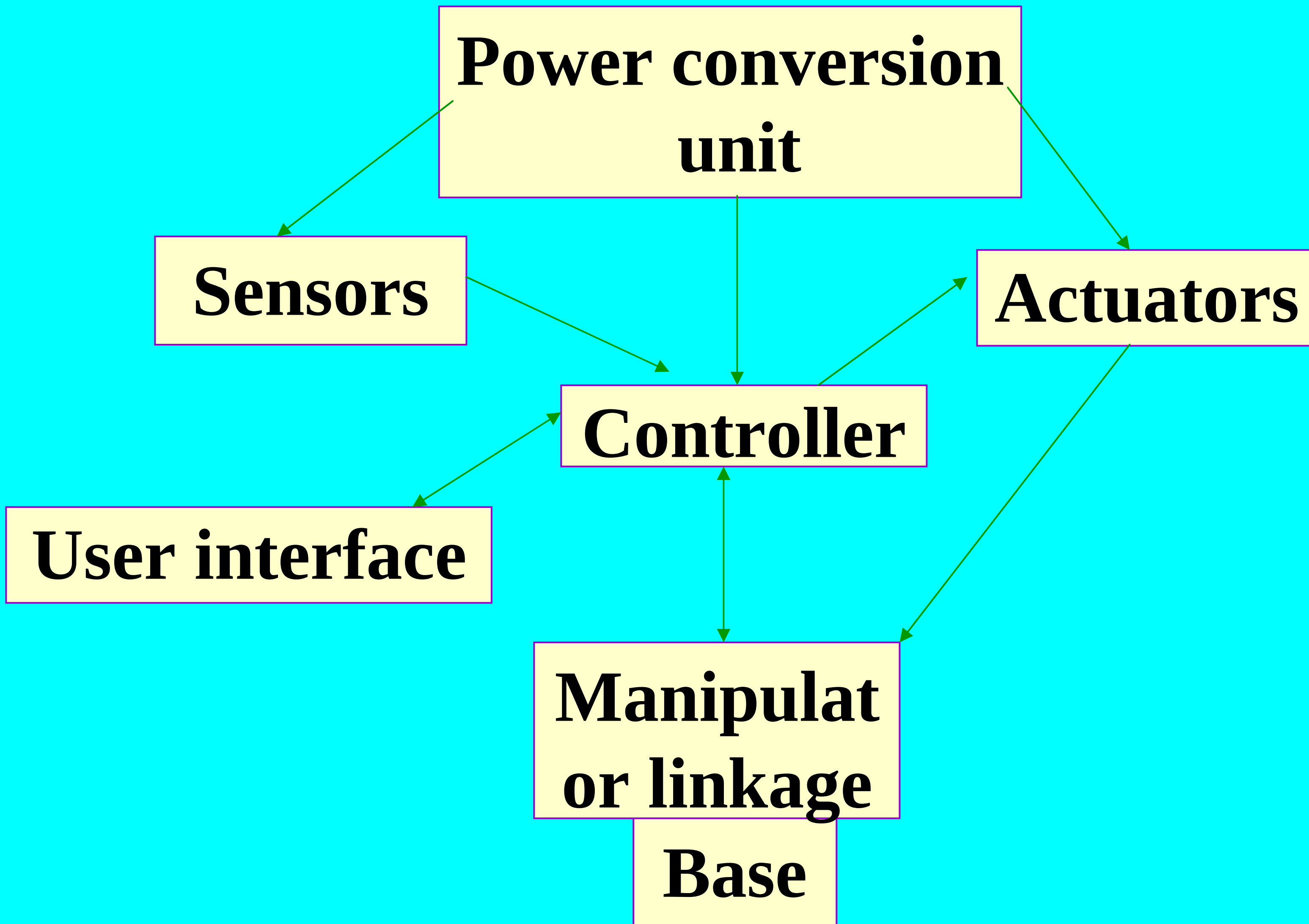
2003: NASA's Mars Exploration Rovers will launch toward Mars in search of answers about the history of water on Mars

Knowledgebase for Robotics

- Typical knowledgebase for the design and operation of robotics systems
  - Dynamic system modeling and analysis
  - Feedback control
  - Sensors and signal conditioning
  - Actuators (muscles) and power electronics
  - Hardware/computer interfacing
  - Computer programming

Disciplines: mathematics, physics, biology, mechanical engineering, electrical engineering, computer engineering, and computer science

Key Components

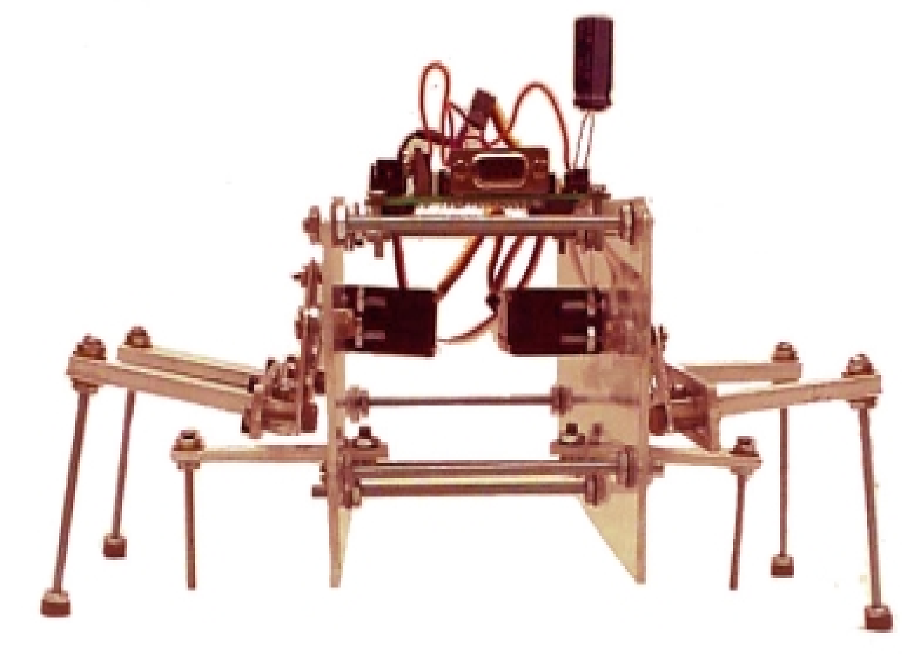


Robot Base: Fixed v/s Mobile

Robotic manipulators used in manufacturing are examples of fixed robots. They can not move their base away from the work being done.

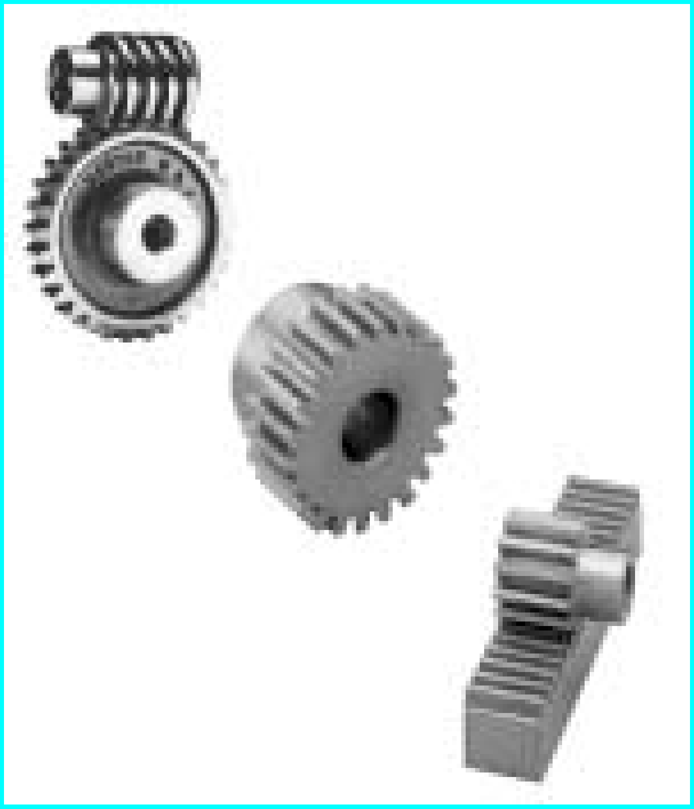
A255 robot

Mobile bases are typically platforms with wheels or tracks attached. Instead of wheels or tracks, some robots employ legs in order to move about.



Robot Mechanism

Mechanical Elements



Sensors

•Human senses: sight, sound, touch, taste, and smell provide us vital information to function and survive

•Robot sensors: measure robot configuration/condition and its environment and send such information to robot controller as electronic signals (e.g., arm position, presence of toxic gas)

•Robots often need information that is beyond 5 human senses (e.g., ability to: see in the dark, detect tiny amounts of invisible radiation, measure movement that is too small or fast for the human eye to see)

Accelerometer
Using Piezoelectric Effect

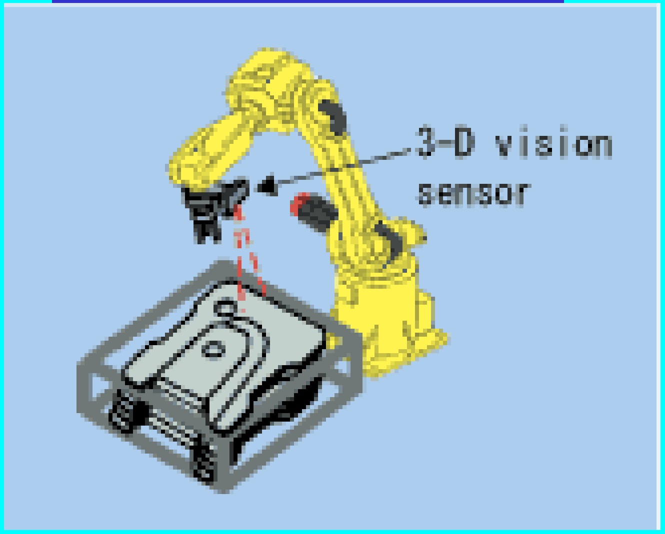
Flexiforce Sensor

Vision Sensors

Vision Sensor: e.g., to pick bins, perform inspection, etc.

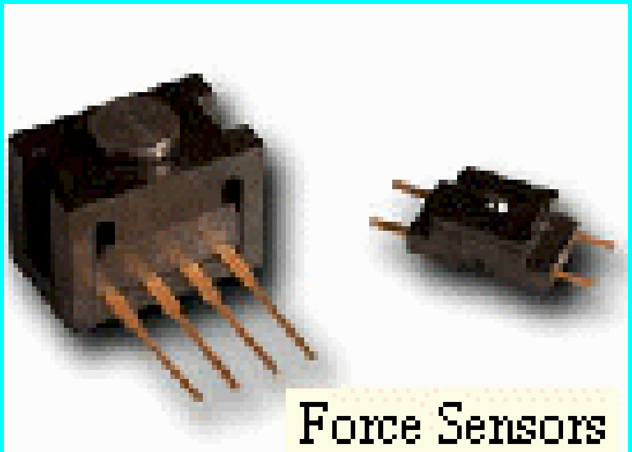
In-Sight Vision Sensors

Part-Picking: Robot can handle work pieces that are randomly piled by using 3-D vision sensor. Since alignment operation, a special parts feeder, and an alignment pallete are not required, an automatic system can be constructed at low cost.

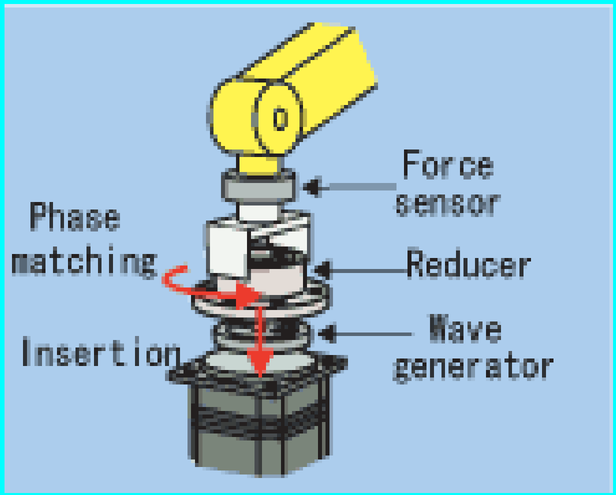


Force Sensors

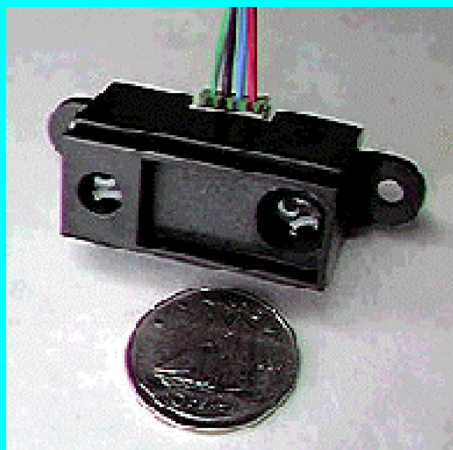
Force Sensor: e.g., parts fitting and insertion, force feedback in robotic surgery



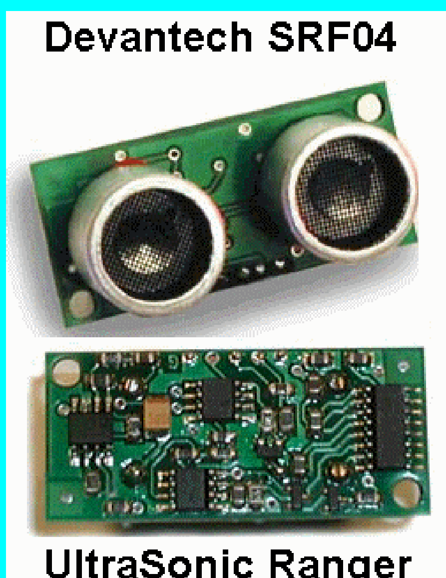
Parts fitting and insertion: Robots can do precise fitting and insertion of machine parts by using force sensor. A robot can insert parts that have the phases after matching their phases in addition to simply inserting them. It can automate high-skill jobs.



Proximity Sensors



Infrared Ranging Sensor



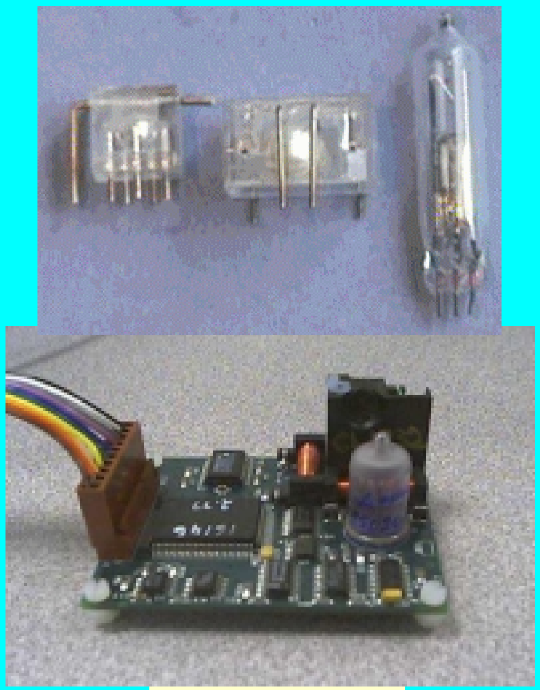
Example

KOALA ROBOT

- 6 ultrasonic sonar transducers to explore wide, open areas
- Obstacle detection over a wide range from 15cm to 3m
- 16 built-in infrared proximity sensors (range 5-20cm)
- Infrared sensors act as a “virtual bumper” and allow for negotiating tight spaces

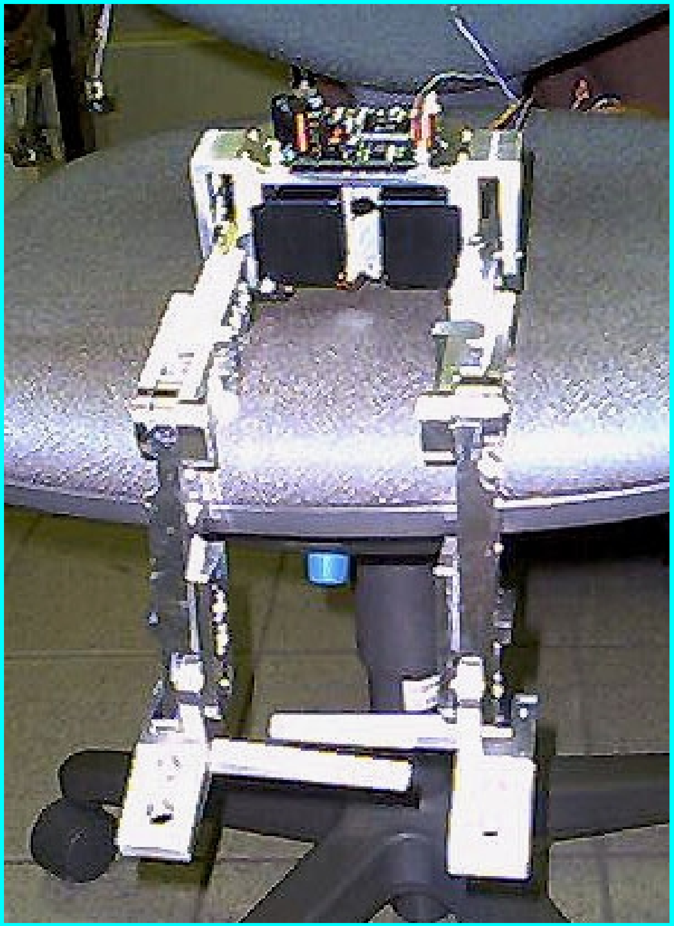
Tilt Sensors

Tilt sensors: e.g., to balance a robot



Tilt Sensor

Example



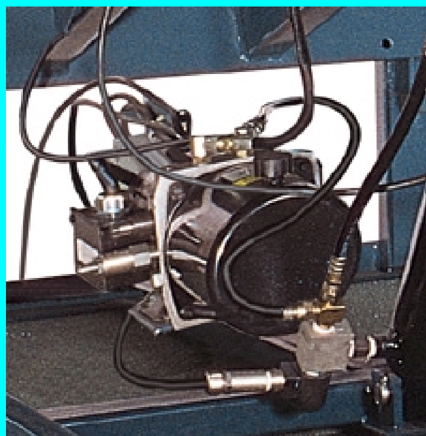
Planar Bipedal Robot

Actuators/Muscles: I

- Common robotic actuators utilize combinations of different electro-mechanical devices
  - Synchronous motor
  - Stepper motor
  - AC servo motor
  - Brushless DC servo motor
  - Brushed DC servo motor

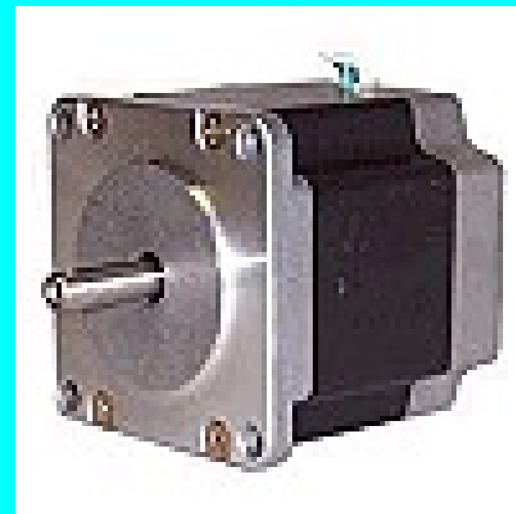
http://www.ab.com/motion/servo/fseries.html

Actuators/Muscles: II



Hydraulic Motor

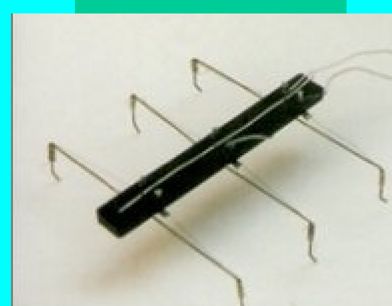
Pneumatic Cylinder



Stepper Motor

DC Motor

Pneumatic Motor



Muscle Wire

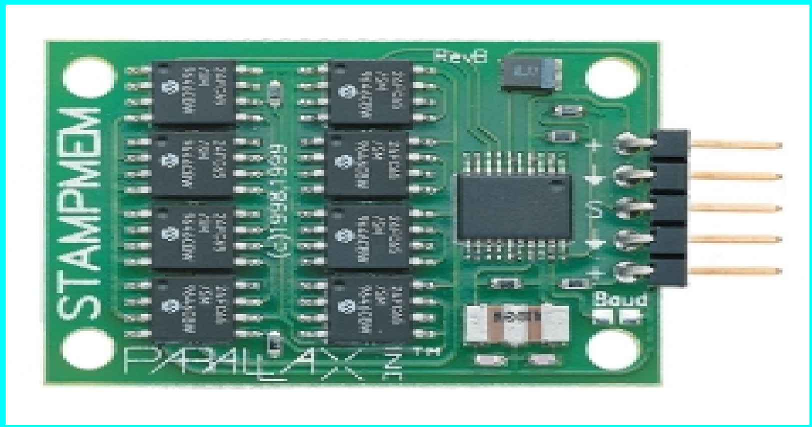
Servo Motor

Controller

- Provide necessary intelligence to control the manipulator/mobile robot
- Process the sensory information and compute the control commands for the actuators to carry out specified tasks

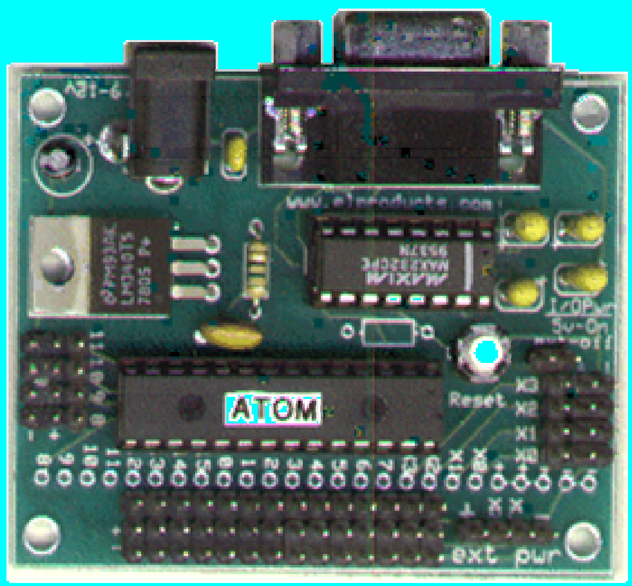
Storage Hardware

Storage devices: e.g., memory to store the control program and the state of the robot system obtained from the sensors

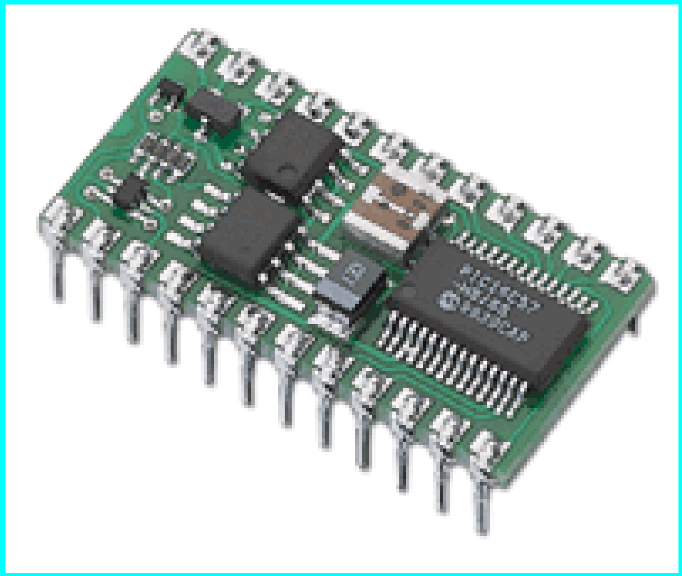


Computation Hardware

Computational engine that computes the control commands



RoboBoard Robotics Controller

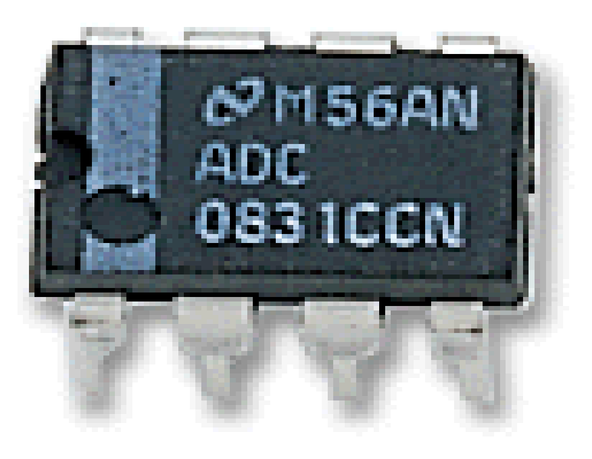


BASIC Stamp 2 Module

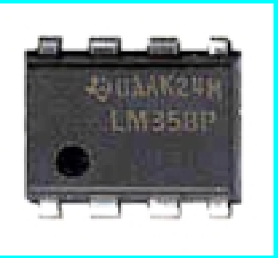
Interface Hardware

Interface units: Hardware to interface digital controller with the external world (sensors and actuators)

Analog to Digital Converter

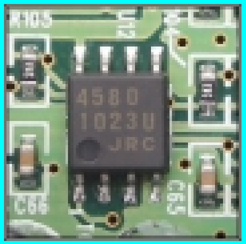


Operational Amplifiers



LM358

LM358



LM1458 dual operational amplifier

Robots in Industry

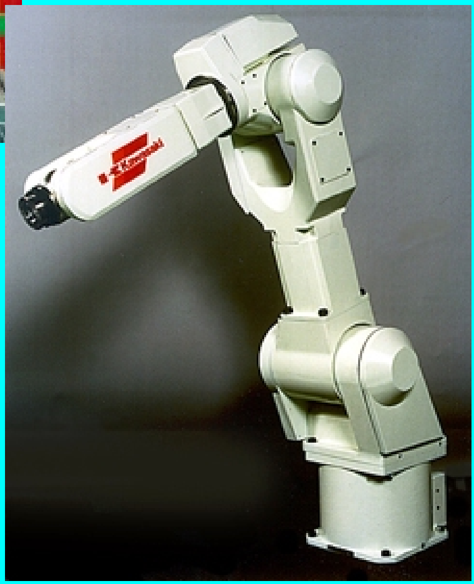
- Agriculture
- Automobile
- Construction
- Entertainment
- Health care: hospitals, patient-care, surgery , research, etc.
- Laboratories: science, engineering , etc.
- Law enforcement: surveillance, patrol, etc.
- Manufacturing
- Military: demining, surveillance, attack, etc.
- Mining, excavation, and exploration
- Transportation: air, ground, rail, space, etc.
- Utilities: gas, water, and electric
- Warehouses

Industrial Applications of Robots

- Material handling
- Material transfer
- Machine loading and/or unloading
- Spot welding
- Continuous arc welding
- Spray coating
- Assembly
- Inspection

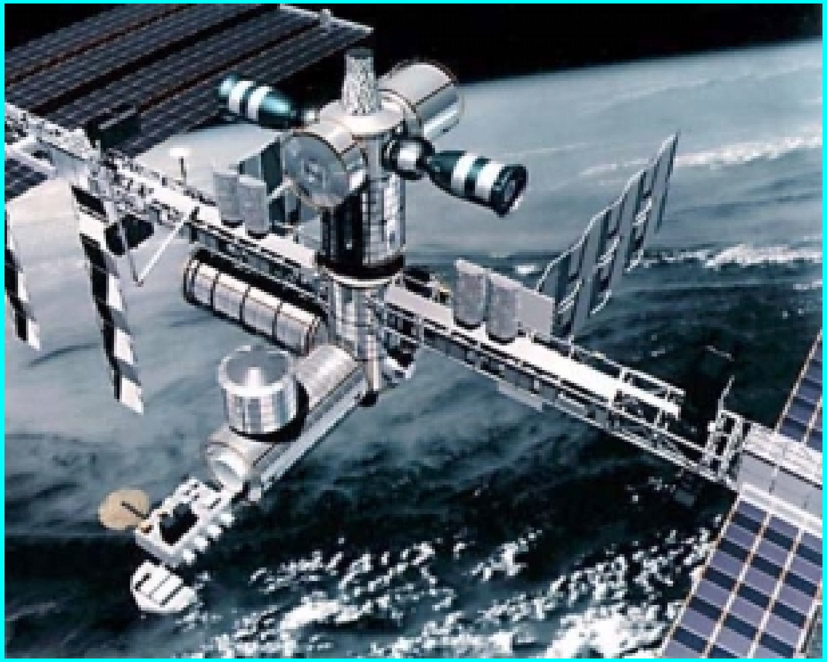
Material Handling Manipulator

Spot Welding Manipulator



Assembly Manipulator

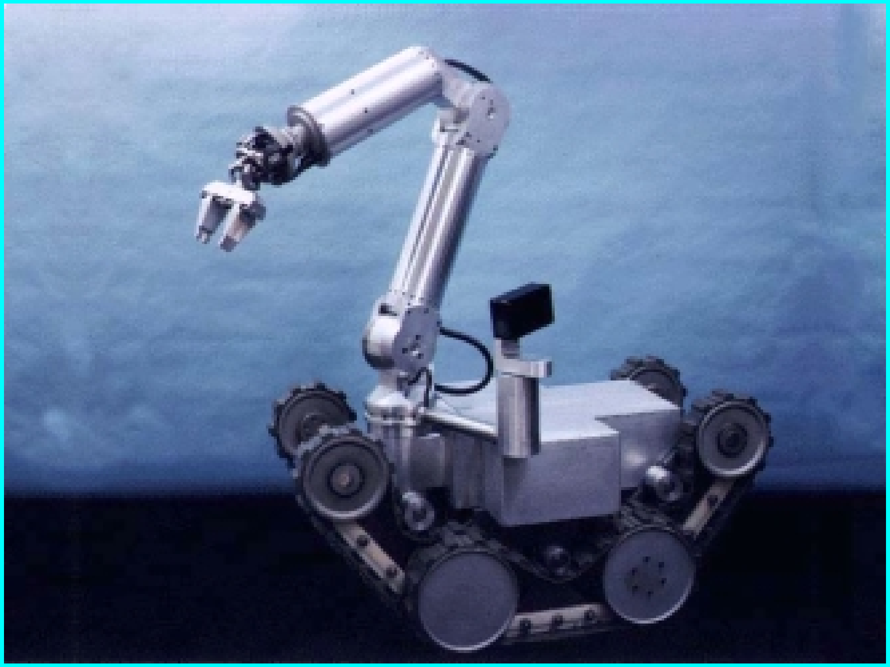
Robots in Space



NASA Space Station

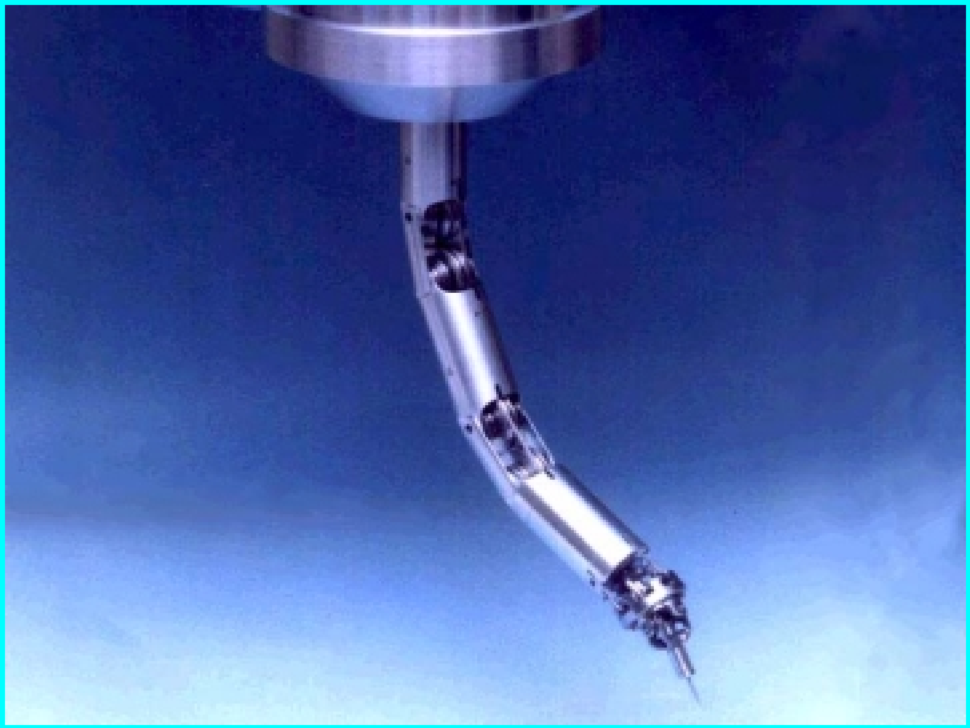
Robots in Hazardous Environments

TROV in Antarctica operating under water



HAZBOT operating in atmospheres containing combustible gases

Medical Robots



Robotic assistant for micro surgery

Robots in Military

SPLIT STRIKE: Deployed from a sub's hull, Manta could dispatch tiny mine-seeking AUVs or engage in more explosive combat.

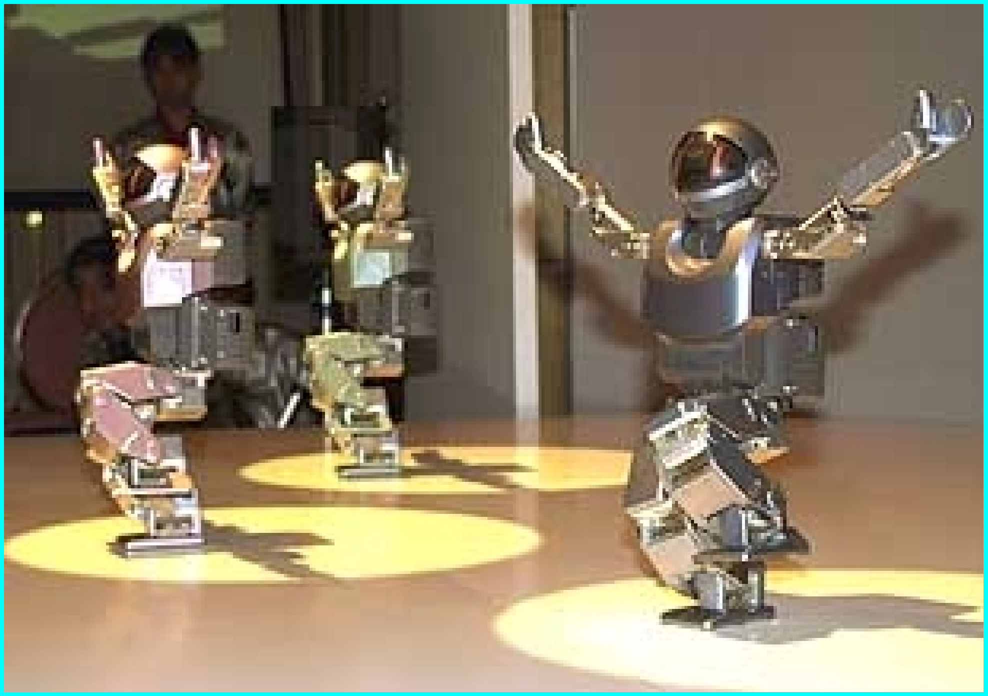
PREDATOR

GLOBAL HAWK

ISTAR

GOLDENEYE

Robots at Home

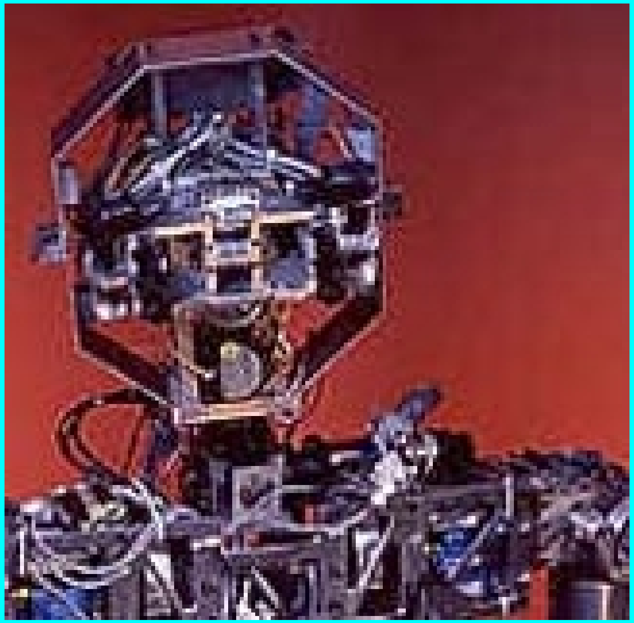


Sony SDR-3X Entertainment Robot

Sony Aido

Future of Robots: I

Artificial Intelligence



Cog

Kismet

Future of Robots: II

Autonomy

Robot Work Crews

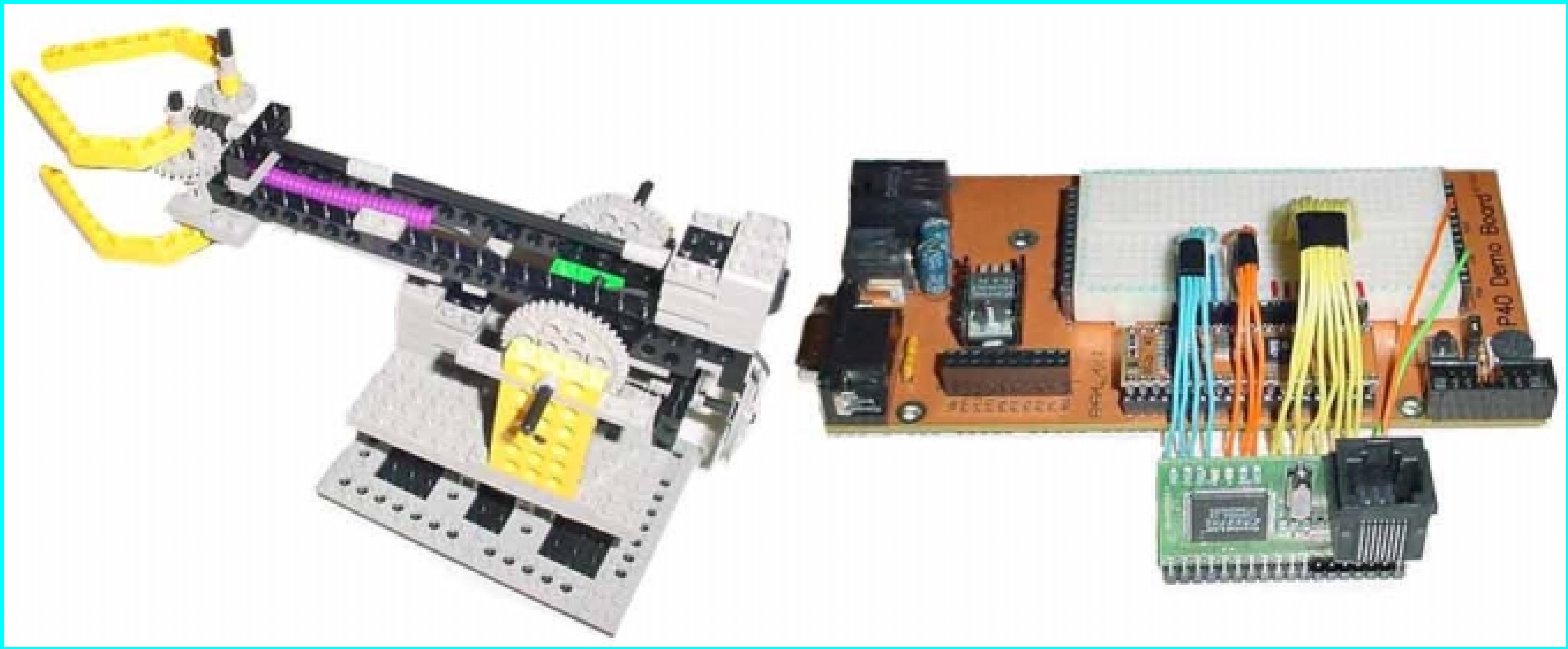
Garbage Collection Cart

Future of Robots: III

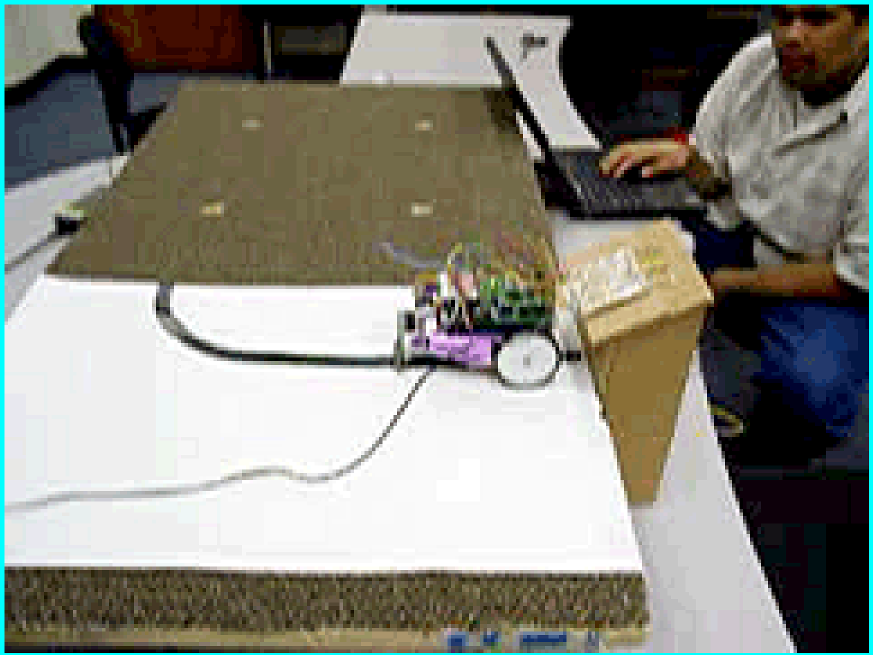
Humanoids

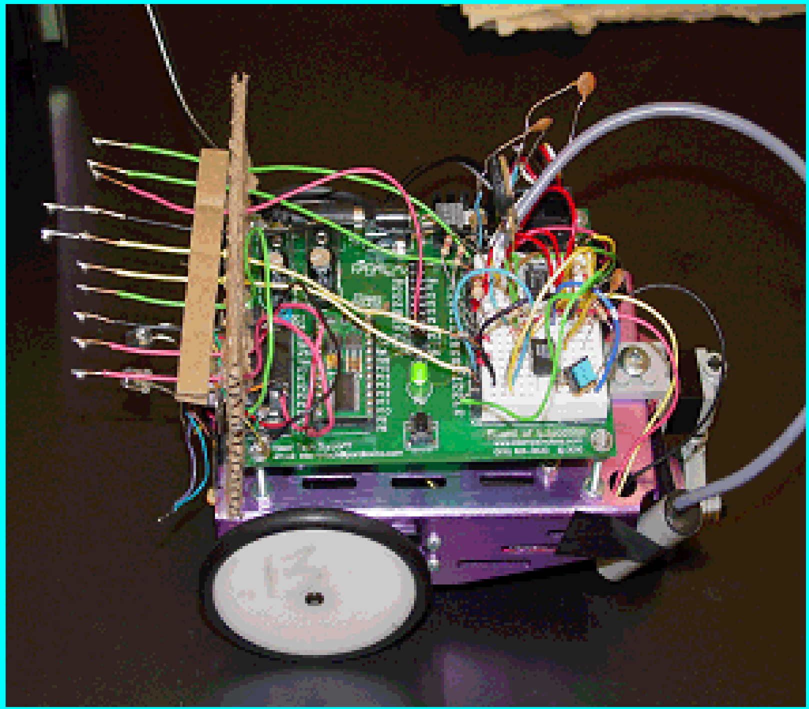
HONDA Humanoid Robot

Robotics @ MPCRL: Remote Robot Arm Manipulation

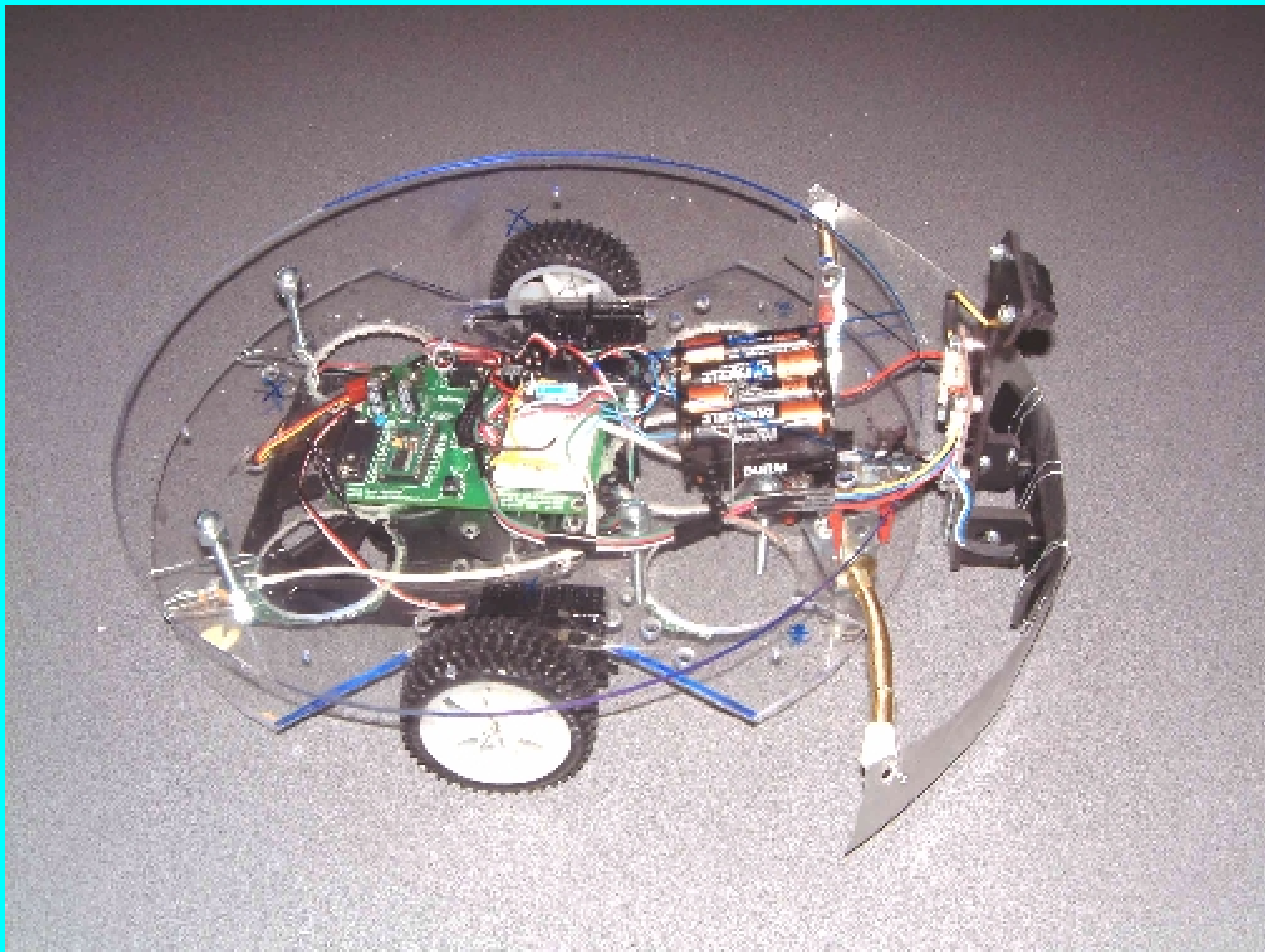


Robotics @ MPCRL: Smart Irrigation System

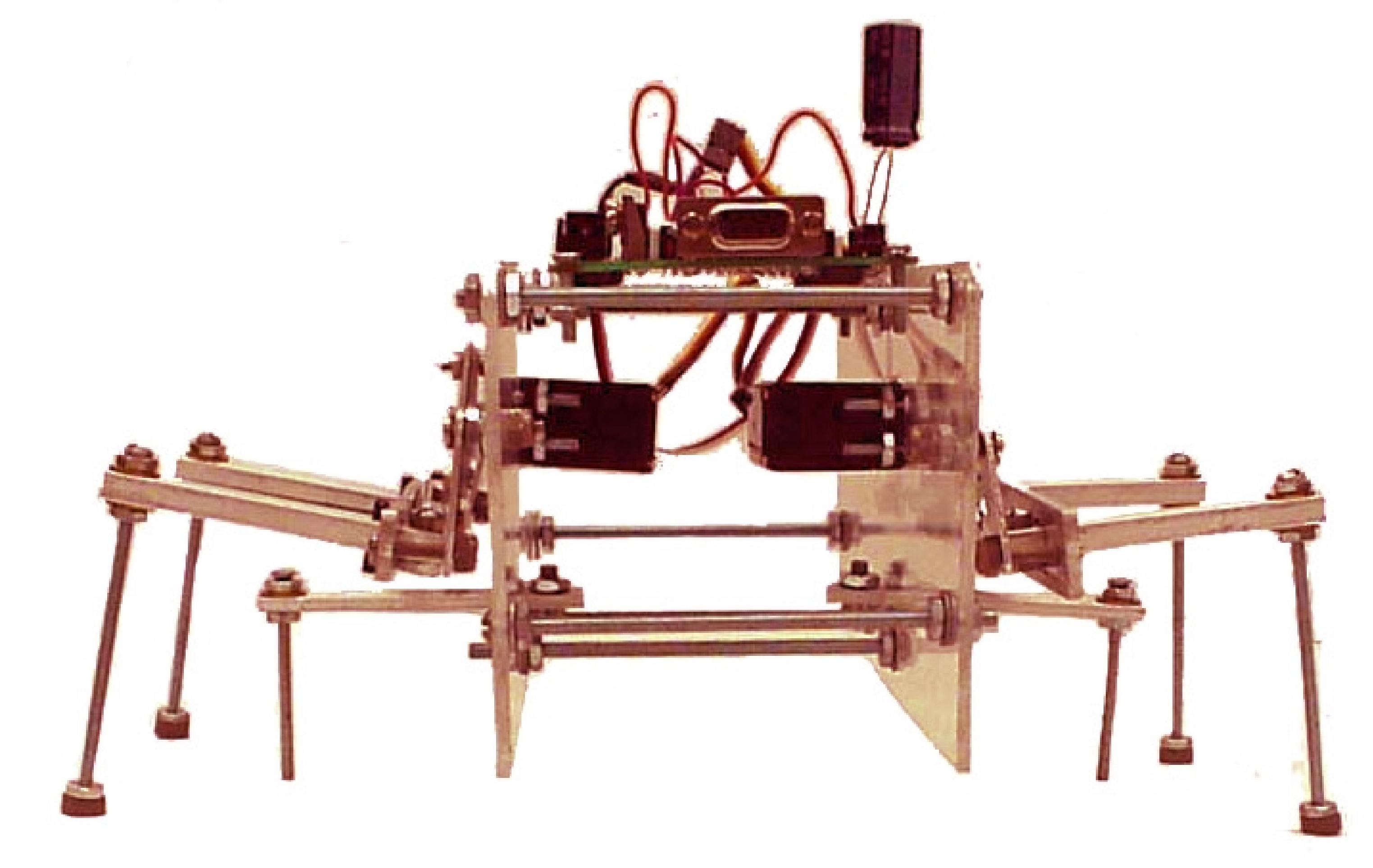




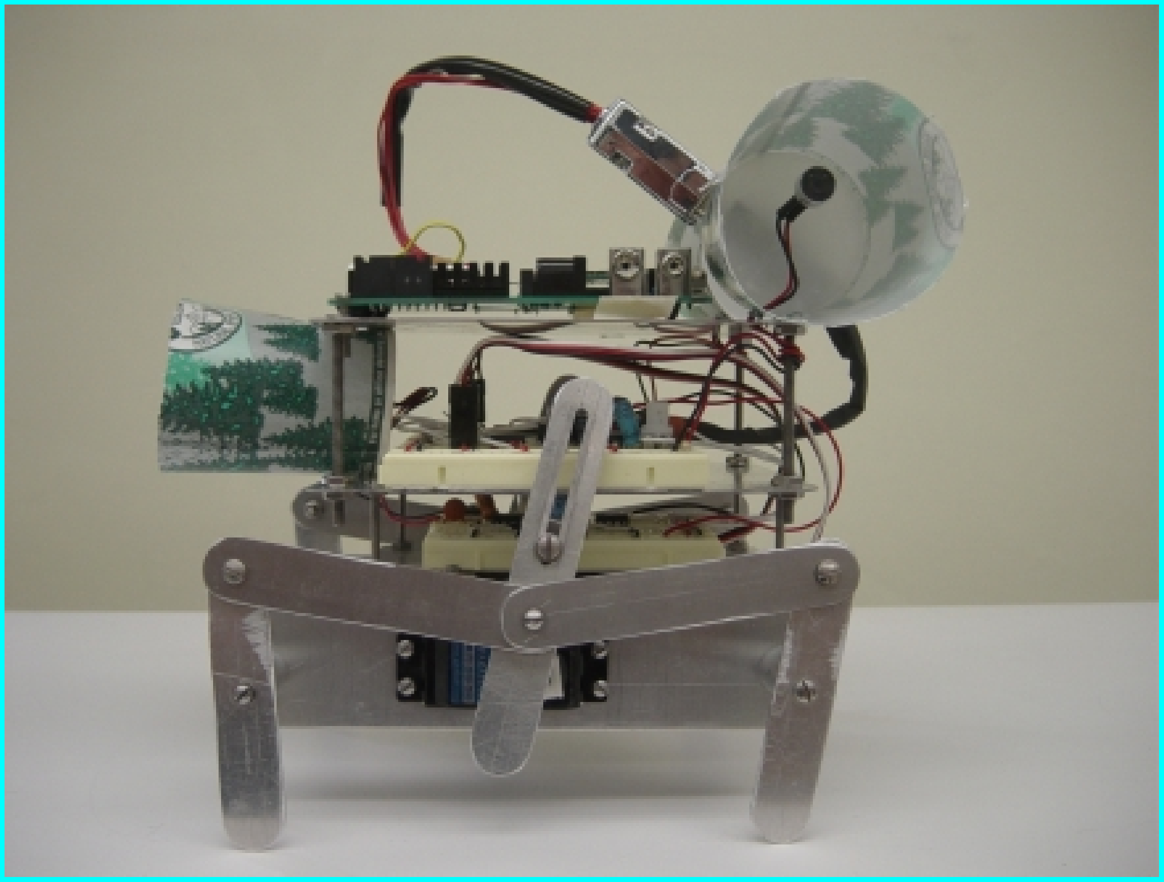
Robotics @ MPCRL: RoboDry



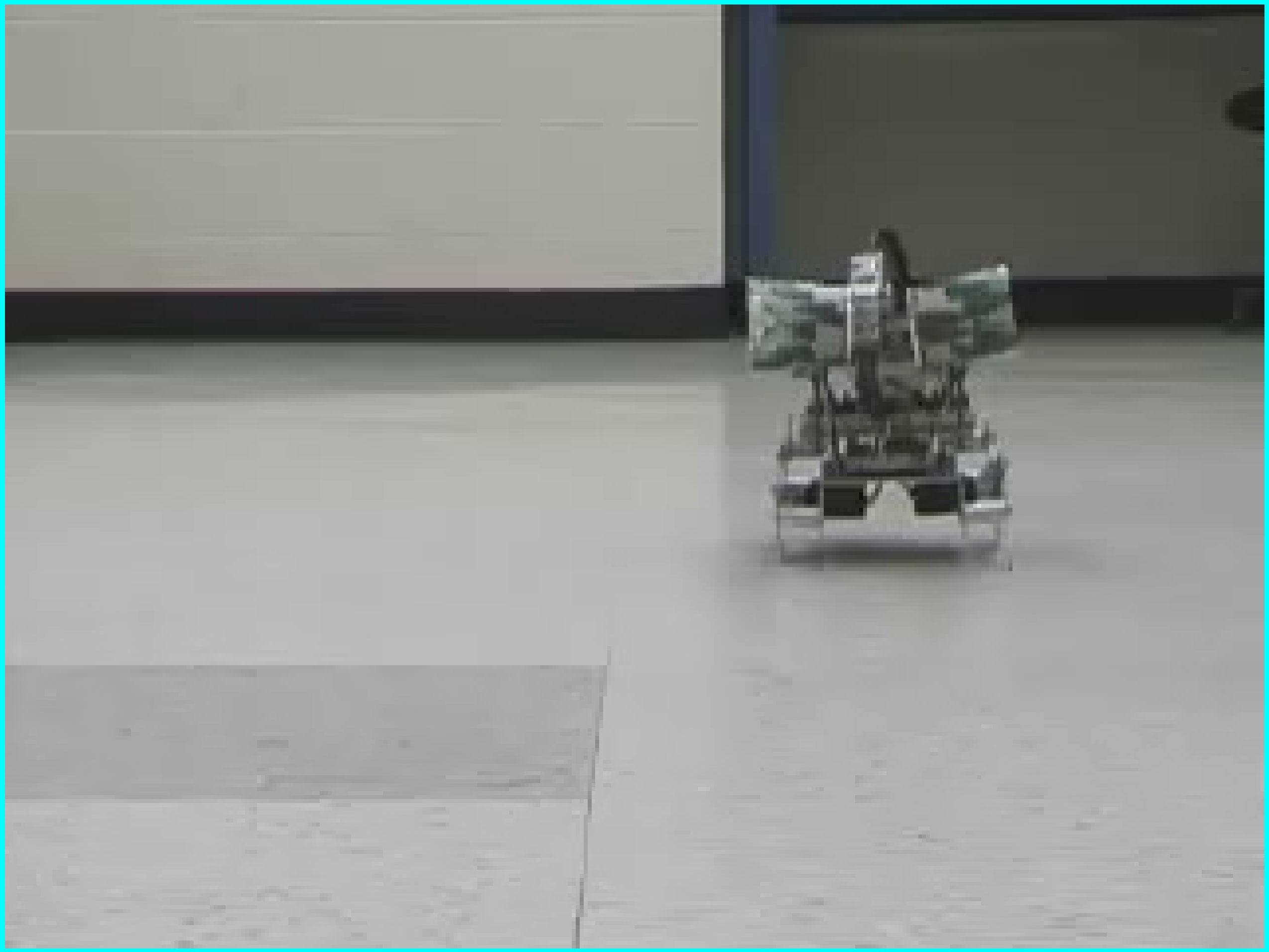
Robotics @ MPCRL:
4-Legged Hexapod



Robotics @ MPCRL: Hexapod for Disaster Recovery

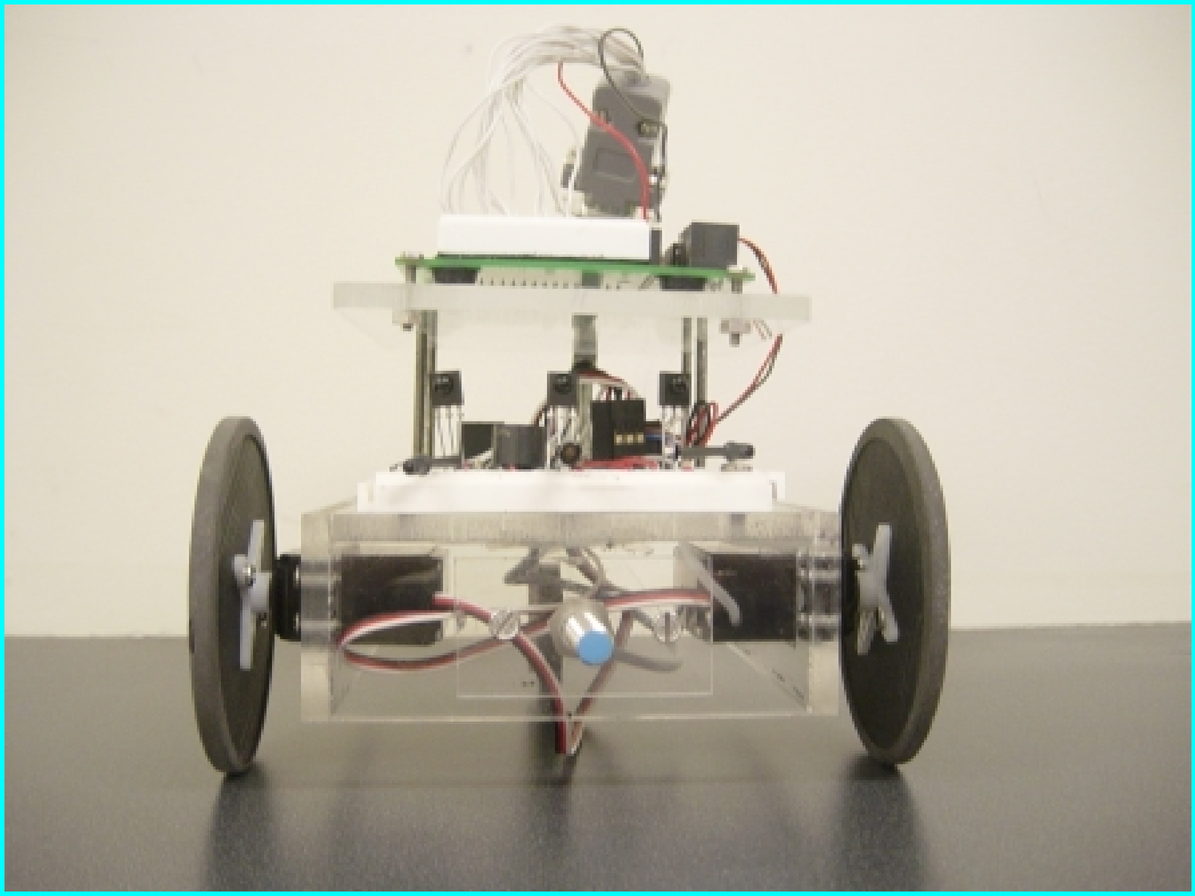


Robotics @ MPCRL: Hexapod for Disaster Recovery



Robotics @ MPCRL: Robotic Vacuum Cleaner

Robotics @ MPCRL: Automated Distinguisher



Robotics @ MPCRL: Automated Distinguisher

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