ROBOTICS:
FROM INDUSTRIAL ROBOTS TO HUMANOIDS

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What is ROBOTICS?

- Its a interdisciplinary field related to designing, applying and using Robots in human endeavors.

What is a Robot?

- A robot is a programmable, multi-functional manipulator designed to move material, parts or specialized devices through variable programmed motions for the performance of a variety of tasks. (RIA)

Robot (Definition)

- A robot is the embodiment of manipulative, locomotive, perceptive, communicative and cognitive abilities in an artificial body, which may or may not have a human shape. It can advantageously be deployed as a tool, to perform different tasks in various environments.

Classification of Robots

- Class1: Manual Handling Devices
- Class 2: Fixed Sequence Robots
- Class 3: Variable Sequence Robots
- Class 4: Playback Robot
- Class 5: Numerical Control Robot
- Class 6: Intelligent Robots

(JIRA)

(RIA- from 3 to 6)

Classification of Robots (contd.)

- Type A: Handling Devices with manual control to telerobotics
- Type B: Automatic handling devices with predetermined cycles
- Types C: Programmable, servo controlled robots with continuous or point to point trajectories
- Type D: same as type C, but capability t acquire information from its environment

(AFR)

Advantages of Robots

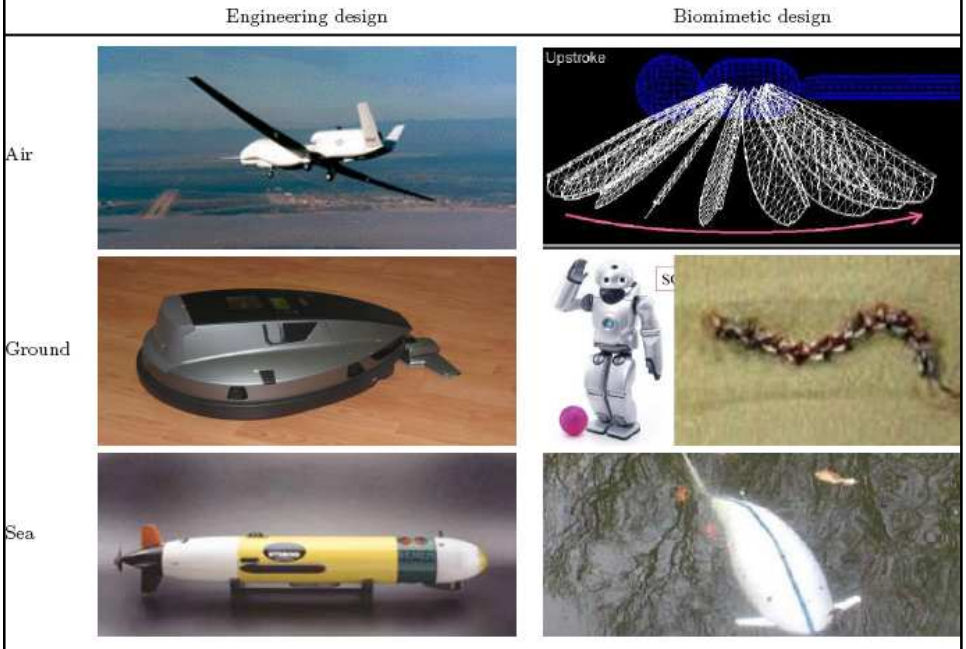
- Increased Productivity
- Increased Flexibility
- More efficiency
- Safety (human, machine and product)
- Can work in Hazardous environment
- Accuracy
- Repeatability
- No environmental comfort needed
- Continuous work without fatigue and boredom
- Don’t get mad or don’t have hangovers
- No medical insurance or vacations
- Scientific Discipline
- process multiple stimuli simultanously

Disadvantages of Robots

- Unemployment (major problem)
- Economic problem (salary)
- Dissatisfaction and resentment among workers
- Lack capability to respond in emergencies
- Lack of decision making power
- Limitations (DOFs, Dexterity, sensors, real time response etc.)
- High initial cost
- Need for periphirals, training, and programming

Types of Robots

- Robotic Vehicles
  - Military and defense systems
  - Space robotic vehicles
  - Field robots
  - Flying Robots
  - Undersea robots
  - Search-and-rescue robotics
  - Personal and service robotic
  - Biomimetic mobile robots
  - Transportation systems
- Space Robotics
- Humanoids
- Industrial Robots
- Biological and Medical Robots
- Networked Robots



Solar-powered AUV (Autonomous Undersea Systems Institute (AUSI).

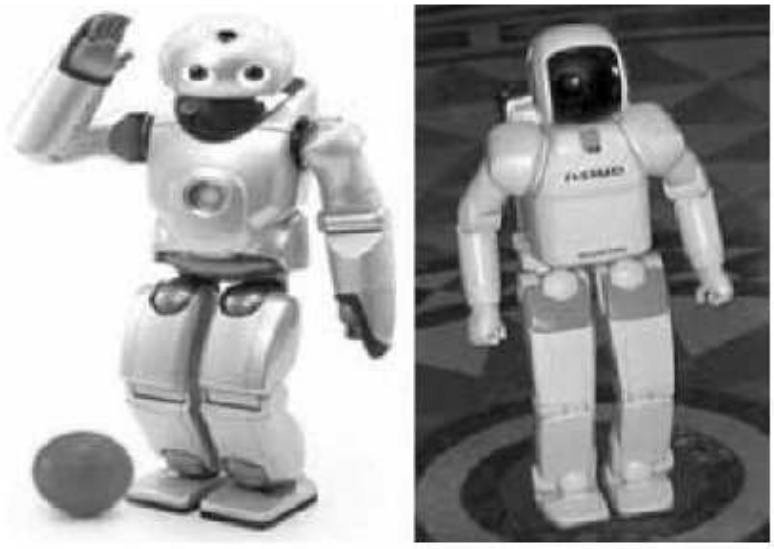
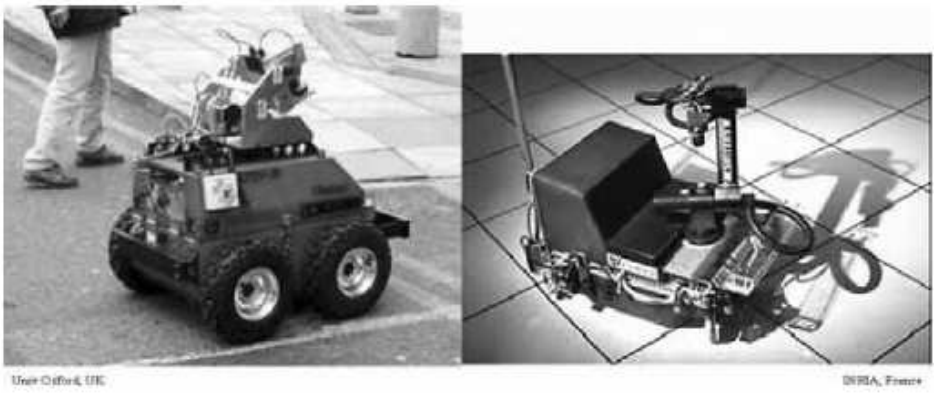


Fig. 2.5. Humanoid robots with locomotion (left: Sony, right: Honda).

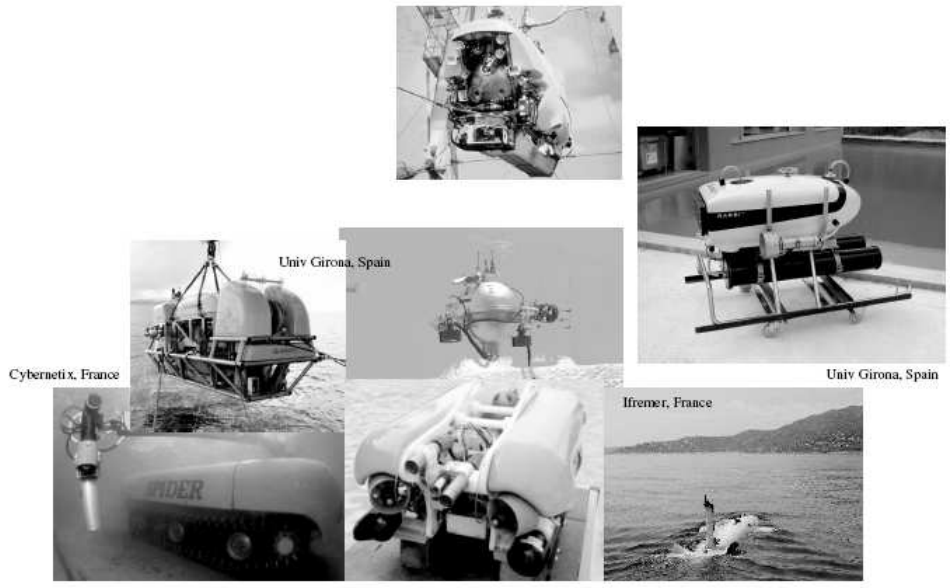
; 2.1. NASA Mars rover (NASA Jet Propulsion Laboratory (JPL)).

IBOT advanced wheel chair (DEKA, the United States).

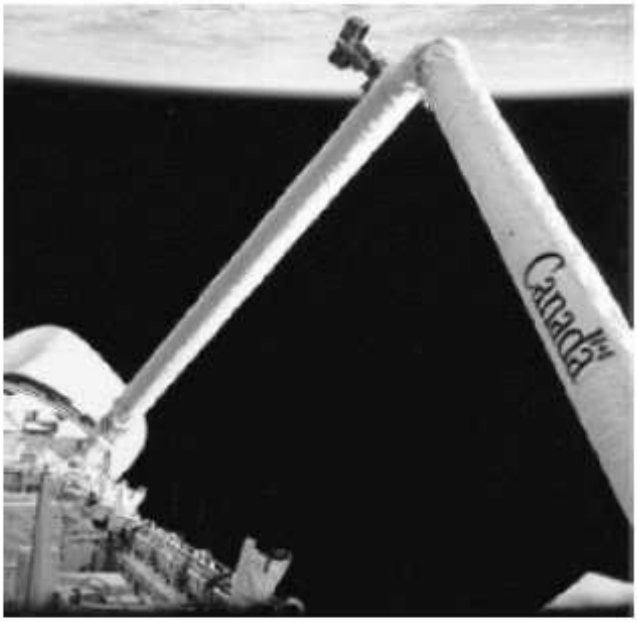
2. Search-and-rescue robotics (CRASAR, USF, the United States).



Prototype vehicles used in urban and indoor settings.



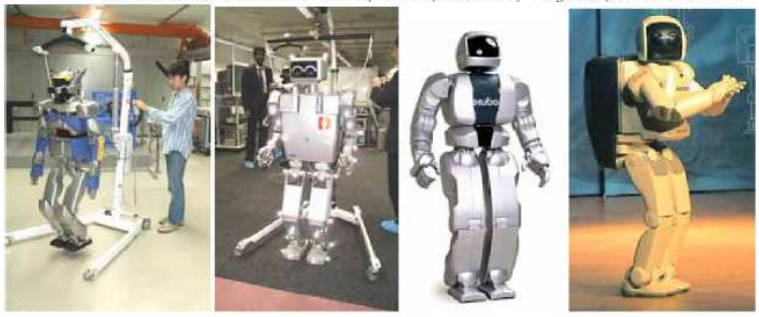
Undersea robotic vehicles.



Space Shuttle robot arm developed by Canadian Space Agency.

Robonaut performing dexterous grasp.

Humanoids from Honda, MIT, Sarcos, Toyota, and NASA.



ZMP walkers at AIST Tsukuba, AIST Waterfront, KAIST, and Honda.

Tennisball collector (GER)

Swisslog (GER)

Electrolux (SWE)

Fujitsu (JAP)

Manus (NET)

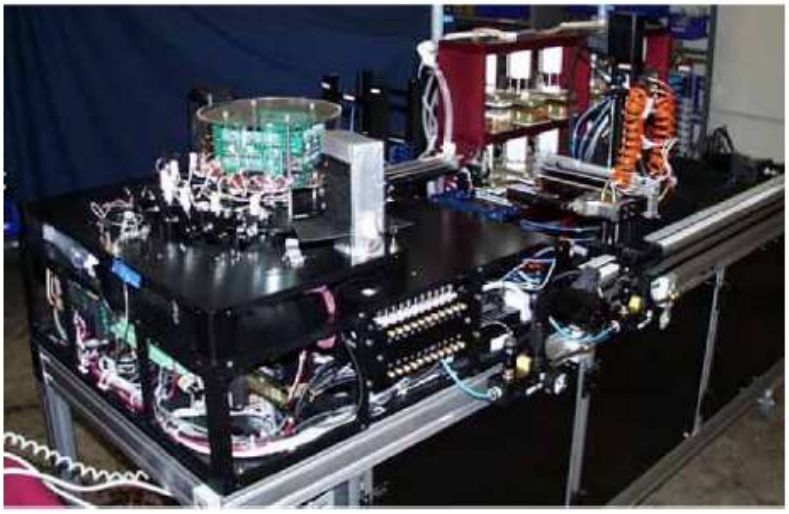
Pool cleaner (SWE)

Window cleaner (GER)

Auto Mower (SWE)

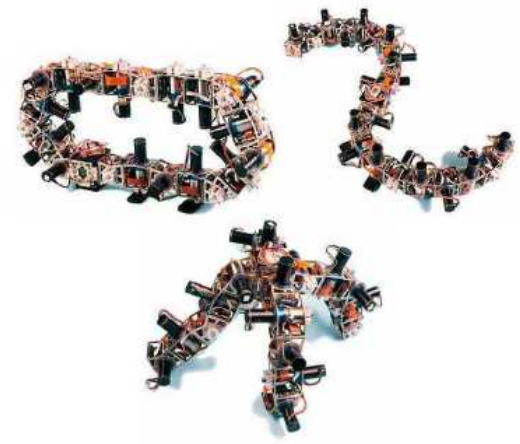
Examples of Service robots.

The ABB pick-and-place robot capable of performing two pick-and-place operations per second.



High-throughput systems for DNA sequencing (University of Washington)

Medical robot facilities at the Berlin Center for Mechatronical Medical Devices



Robotic modules (PARC/University of Pennsylvania can be reconfigured to "morph" into different locomotion systems including a wheel-like rolling system (top left), a snake-like undulatory locomotion system (top right), and a four-legged walking system (bottom).

Impact of Humanoid Robots

- Manufactuing Industry
- For maintenance, diagnostics, and security of Industries
- Construction of Buildings
- Robot Assisted Healthcare
- Robot Assisted Education at Home and Schools
- Robot Assisted Telepresence
- Old houses
- Rehabilitation of patients
- Entertainment
- Education (Mechatronics)
- Research Platform

Humanoid as a Research Platform

- Besides education, which propels research on the humanoid robot, two additional forces which simultaneously stimulate research in this fascinating field are:

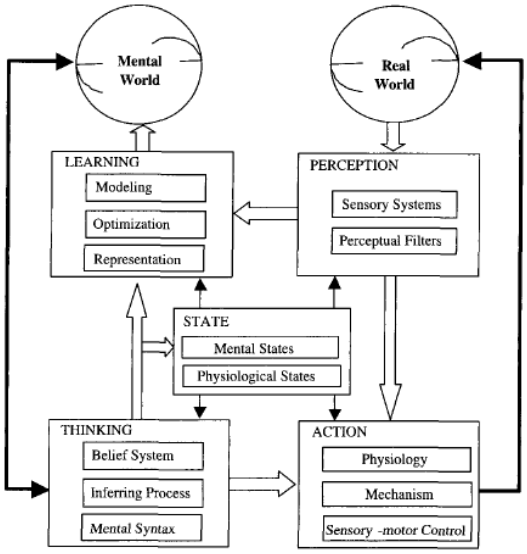
  a) Computational neuroscience and

  b) Intelligent (physical) systems

Computational Neuroscience

- Computational neuroscience is the study of how the human brain plans and controls behaviors to achieve desired results (i.e. outcome)
- An important goal of computational neuroscience is to develop computational theories and models from an understanding of the brain's functions in following important areas.
  - Perception
  - Learning
  - Thinking
  - Action

Computational Neuroscience (contd.)



Intelligence?

- Intelligence is the ability to link perception to actions for the purpose of achieving an intended outcome. Intelligence is a measurable attribute, and is inversely proportional to the effort spent in achieving the intended goal.

Intelligent (physical) systems

- Intelligent (physical) system is the study of computational principles for the development of perception, learning, decision making and integration in an artificial body. An artificial body requires artificial intelligence in order to adapt to a changing environment for the purpose of better performing the assigned tasks.
- Humanoid robot is a perfect research platform for the study of the embodiment of artificial intelligence with an artificial body.

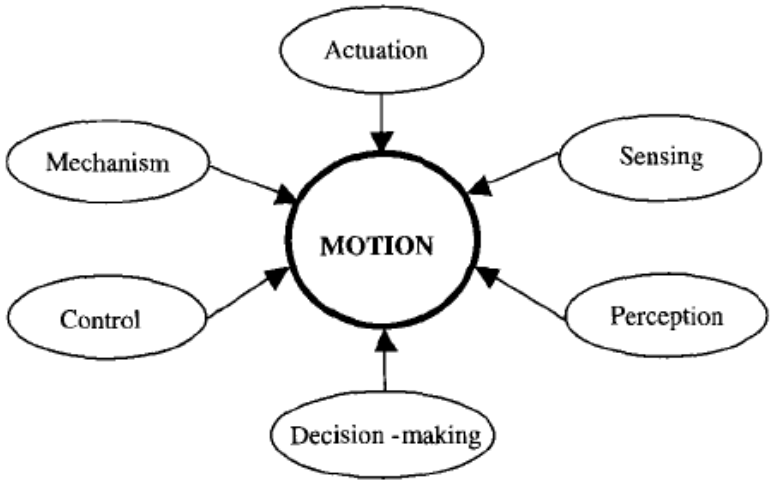
Fundamental Research Challenges

- What are the best leg, spine, and upper limb arrangements, in both mechanisms and sensors, to enable energy-efficient walking?
- How should robots represent knowledge about objects perceived, avoided, and handled in the environment?
- What are the algorithms for using upper body momentum management in driving lower body legs and wheeled balancers?
- How can a mobile manipulation robot place its body to facilitate inspection and manipulation in a complex workspace, where a small footprint and high reach requirements collide?
- How should vision/laser-based perception be combined with tactile/ haptic perception to grasp objects?
- What roles do motion and appearance have in making people accept and work with robots?
- How can people interact with humanoids to form effective and safe teams?

Key technologies for Humanoid Robotics

- Improved design and packaging of systems with new component technologies that are smaller, stronger, faster, and offer better resolution and accuracy.
- Dense and powerful energy storage for longer endurance, heavy lifting, and speed.
- Improved actuators that have higher power densities, including auxiliary subsystems such as power supplies, signal conditioning, drive trains, and cabling.
- Improved speed reduction and mechanisms for transferring power to the humanoid's extremities. Improved force control for whole body dynamics.
- Better tactile skins for sensing contact, touch, and proximity to objects in the environment.
- Advanced navigation that perceives and selects footfalls with 1-cm scale accuracy at high body speed. Vestibular systems for coordinating upper limbs and head-mounted sensors on dynamic bodies. Dexterous feet for dynamic running and jumping.
- Dexterous hands for tool use and handling of general objects.

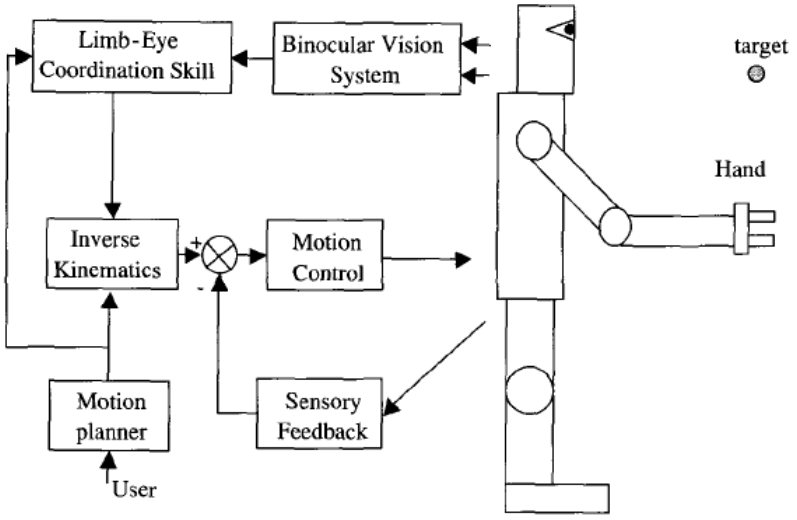
Issues in Robotics



Issues in Robotics (contd.)

1. Mechanism and Kinematics
2. Actuation Elements and Dynamics
3. Sensing Elements
4. Control System
5. Information and Decision Making
6. Visual Perception

Vision guided Manipulation



"The Theoretical and Practical Knowledge are the best signs of distinction and deep thinking presents the clearest picture of every problem"

Hazrat Ali (A.S.)