Fundamental of Cognitive Interaction with Robots

Lecture 5

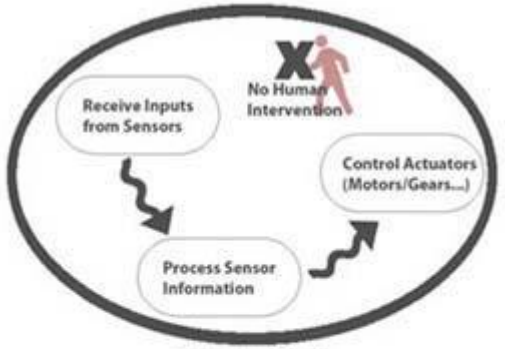
Classification of Robots

- Before we plan to design and build a robot, we need to understand the purpose of a robot. There are many different kinds of robots available, each created for different tasks and behavior.
- Robots can be built for entertainment, competitions, domestic help, industrial uses, etc.
- Each of these robots can be classified as **autonomous**, **controlled** or **semi-autonomous** based on the way they are controlled.

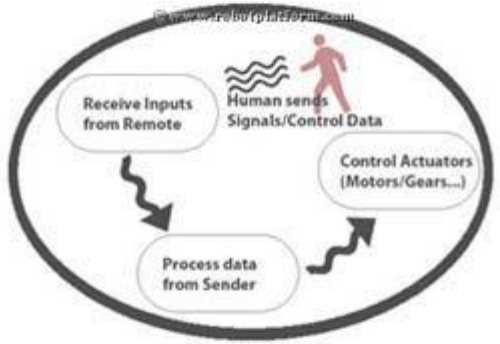
Classification of Robots

Autonomous robots

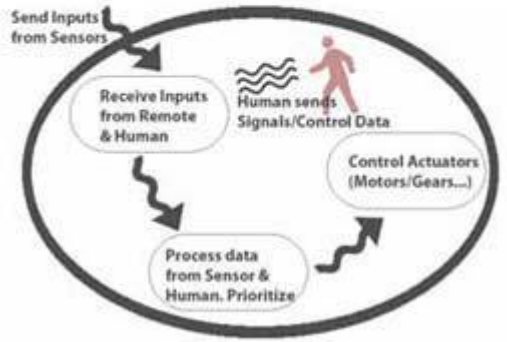
- Autonomous robots works autonomously without intervention from human.
- They take decisions based on situations and surroundings.
- Autonomous robots can be as simple as an obstacle avoider, or as complex as an intellectual humanoid. However due to restrictions in power, size and intelligence these robots may not be good enough to perform complicated tasks.



Autonomous Robots



Controlled Robots

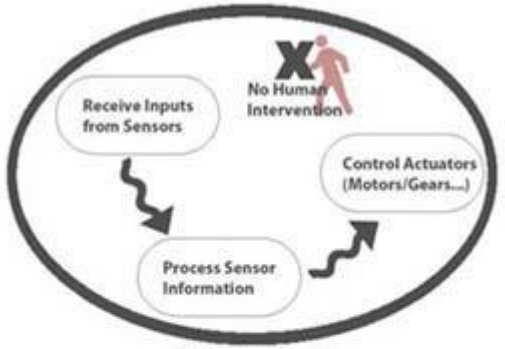


Semi-Controlled Robots

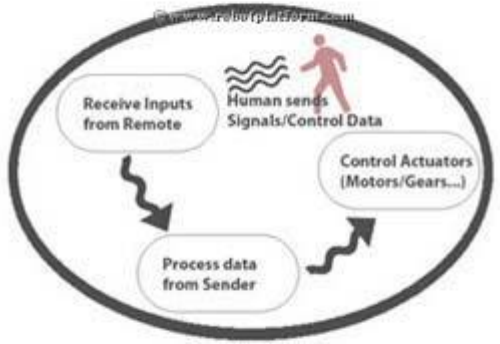
Classification of Robots

Controlled Robots

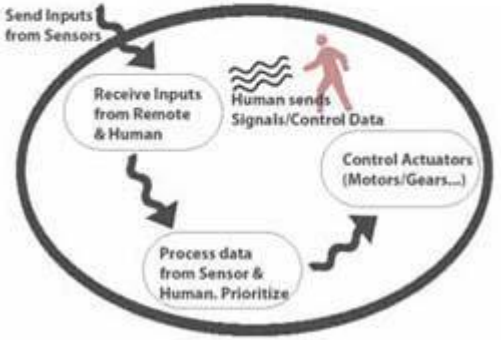
- These are robots that require human intervention to accomplish a task.
- They can either be wire controlled or remote controlled that are guided to perform any kind of complicated activities.
- A remote controlled robot can be programmed and guided to perform dangerous and complex tasks without being on the spot.



Autonomous Robots



Controlled Robots

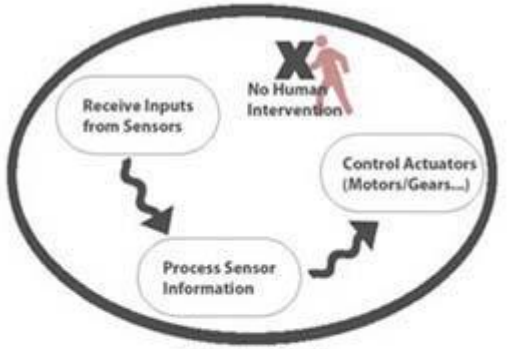


Semi-Controlled Robots

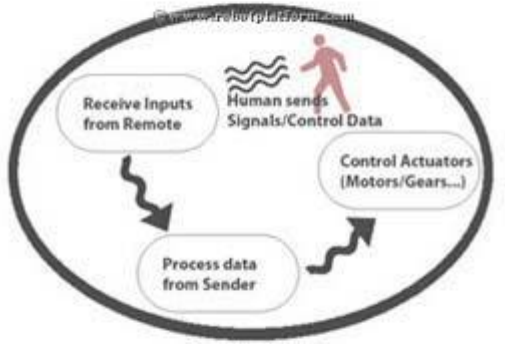
Classification of Robots

Semi-Autonomous robots

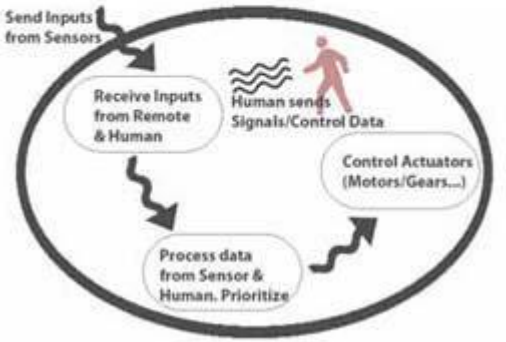
- These robots take the best of both worlds.
- The built-in intelligence helps them perform simple tasks and take simple decisions.
- For complex tasks, human intervention may be required.
- Generally, the program is designed to take intelligent decisions on its own until any human input.



Autonomous Robots



Controlled Robots

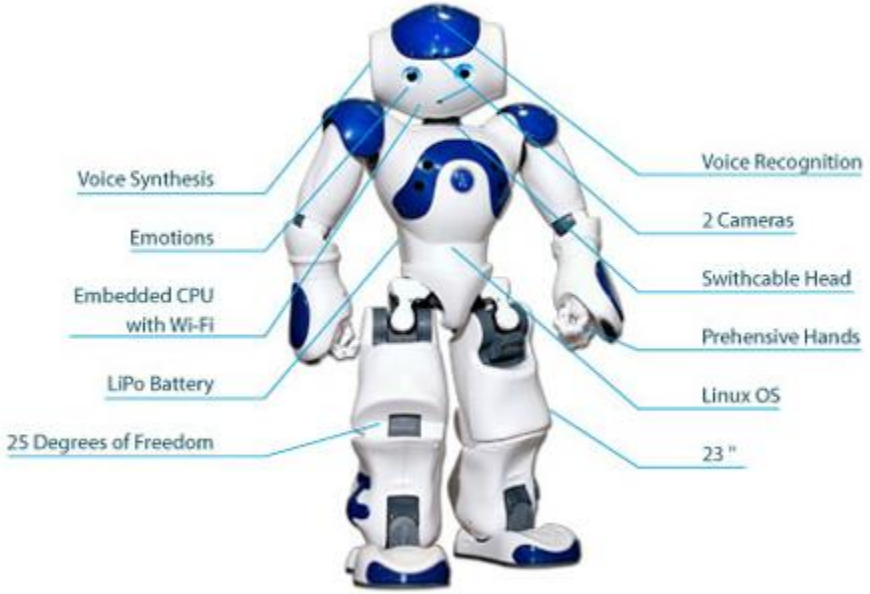


Semi-Controlled Robots

Main Components of Robots

1- Body/Frame

- The body or frame can be of any shape and size.
- Essentially, the body/frame provides the structure of the robot.

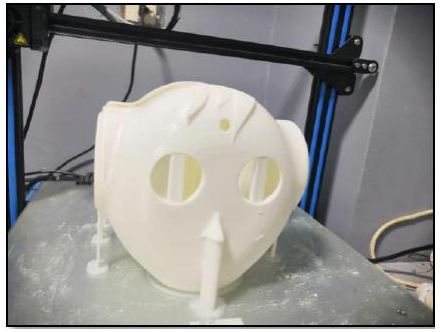


Material:

- Plastic
- Wood
- Metal

Fabrication:

- Casting
- 3D Printing



Main Components of Robots

2- Robot Locomotion

- Locomotion is the method of moving from one place to another.
- The mechanism that makes a robot capable of moving in its environment is called as robot locomotion.

Types of locomotion:

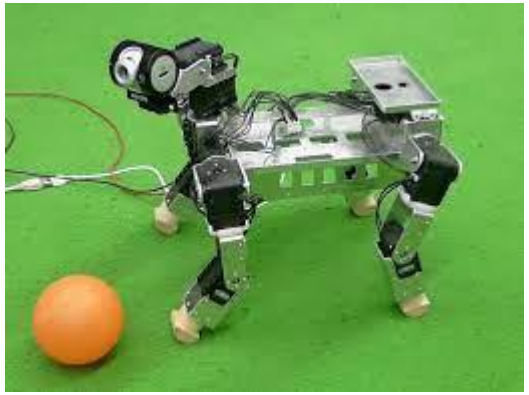
- Wheeled
- Legged
- Tracked slip/skid
- Combination of legged and wheeled locomotion

Main Components of Robots

2- Robot Locomotion

A- Legged locomotion

- It comes up with the variety of two, four, and six legs. If a robot has multiple legs, then leg coordination is required for locomotion.
- Legged locomotion consumes more power while demonstrating jump, hop, walk, climb up or down etc.
- It requires more number of motors to accomplish a movement.
- It is suited for rough as well as smooth terrain where irregular or too smooth surface makes it consume more operational power.
- It is difficult to implement because of stability issues.



Main Components of Robots

2- Robot Locomotion

A- Legged locomotion (Cont.)

- The total number of possible gaits (a periodic sequence of release and lift events for each of the total legs) of a robot depends on the number of robot legs.
- If a robot has K legs, then the number of possible events is,

$$N = (2K - 1)!$$

- In case of a two-legged robot (K=2), therefore the number of possible events is 6.

  The six possible different events:-

  - Lifting the Right leg
  - Lifting the Left leg
  - Releasing the right leg
  - Releasing the left leg
  - Releasing both the legs together
  - Lifting both the legs together
- In case of K=4 legs, there are 5040 possible events. Hence the complexity of robots is dependent on number of legs of robots. On increasing legs of a robot the complexity of robotic system increases.

Main Components of Robots

2- Robot Locomotion

B- Wheeled Locomotion

- Wheels are best for robots as they are easy to design, implement and practical for robots that require speed.
- They do not suffer from static or dynamic stability as the center of gravity of robot does not change when they are in motion or just standing still.
- It requires less number of motors for accomplishing a movement.
- It is more power efficient as compared to legged locomotion.
- The disadvantage is that they are not stable on uneven or rough terrain and also on extremely smooth surfaces as they tend to slip.

Main Components of Robots

2- Robot Locomotion

B- Wheeled Locomotion (Cont.)

Wheels Types:

- Standard wheel – they are attached to motors and are used to drive and steer the robot
- Orientable wheel – used to orient and balance the robot, not connected to motors
- Ball wheel - The ball has 360° of freedom and is normally used to balance a robot.
- Swedish 45 and Swedish 90 wheels - It is an Omni-wheel, which rotates around the wheel axle, and around the rollers

Main Components of Robots

2- Robot Locomotion

C- Slip/Skid Locomotion

- In Slip/Skid locomotion, the vehicles use tracks as available in a tank.
- The robot is steered by moving tracks with different speeds in the same or opposite direction.
- It offers stability because of large contact area of ground and track.

Main Components of Robots

3- Robot Batteries

- Batteries are required for powering the motors, control unit, sensors, etc.
- There are many kinds of batteries that are available for powering the motors.
- Batteries can be classified as **rechargeable** and **non-rechargeable**.
- The main specifications that should be taken into consideration for selection of a battery are as follow –

  - **Voltage Rating** – It is the maximum terminal voltage between battery terminals.
  - **Current Rating or Capacity Rating** – This is the amount of current a battery can supply for a unit of time measured milliamp-hour (mAh). For example if a battery is rated 2000mAh, then the battery can supply 2 Ampere (2000 milliamps) of current for one hour. If the robot is consuming only 1000mA of current, then your battery runs for 2 hours. Higher current output can be obtained by connecting batteries in parallel.

Main Components of Robots

3- Robot Batteries

- **Number of cycles:** Number of times a battery can be recharged and discharged (applicable for reachable batteries) before the performance drops below expected level.
- **Battery Memory effect:** Also known as lazy battery effect is generally found in few types of rechargeable batteries (especially nickel cadmium batteries). If batteries are charged when they are not fully discharged, they somehow remember the previous discharge point and needs a charge whenever it hits that particular point. For example, if a battery discharges to 50% and you recharge it, next time it wouldn’t run below the 50% mark even if you wanted it to discharge lower.

Main Components of Robots

3- Robot Batteries

Battery Types:

- **Alkaline Battery –** Alkaline batteries are non–rechargeable batteries that come with 1.5 V and 9V ratings. The 9V battery comes in 50 to 500 mAh range. These batteries are low-cost and readily available but it does not last long and discharges quickly.

- **Nickel-Metal Hydride Batteries (Ni-MH)** – Ni-MH batteries are rechargeable, where the voltage rating of each cell is 1.2 V that comes with range from 600 mAh to 3300 mAh. These batteries are a bit costly, but they last longer and have a high current capacity.

Main Components of Robots

3- Robot Batteries

Battery Types:

- **Lead-Acid Batteries –** These are still the cheapest option for high capacity. They require almost no maintenance for several years and can undergo a thousand of charge and discharge cycles. These batteries are widely available in low-cost, but these batteries are like heavy boulders for mobile robots and are not preferred for the hobby robots.

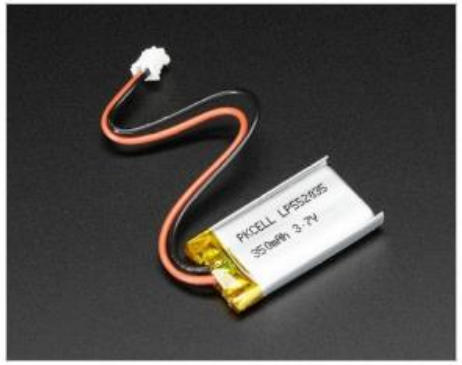
- **Lithium-Ion Batteries (LI-Ion) –** Lithium-ion batteries are rechargeable batteries which are same as used in mobile phones and cameras. Li-Ion batteries come with 3.7 V rating. These batteries are easily available and have high capacity. They are also lightweight.

Main Components of Robots

3- Robot Batteries

Battery Types:

- **Lithium Polymer Batteries (Li-Po) –** These are becoming the most popular type of batteries for use in robotics because of their lightweight, high discharge rates and relatively good capacity, except the voltage ratings are available in increments of 3.7 V.



Main Components of Robots

4- Robot Controller

- The robot controller is a computer system that connects to the robot in order to control the movements of the robot (Robot arm, industrial robot, humanoid, etc.)
- The controllers can be programmed and a set of instructions help in controlling the IO pins through which the robot can interact with the other components or the surrounding world.
- Various controllers can be used with different functionalities.

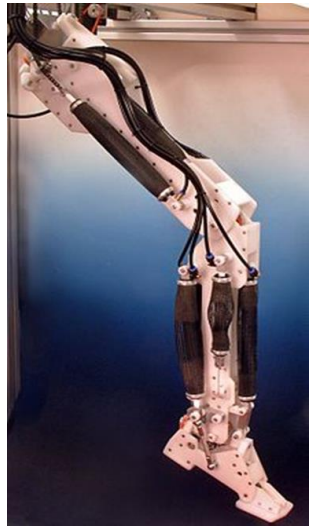
Main Components of Robots

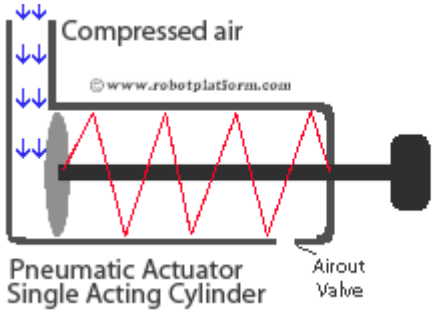
5- Robot Actuators

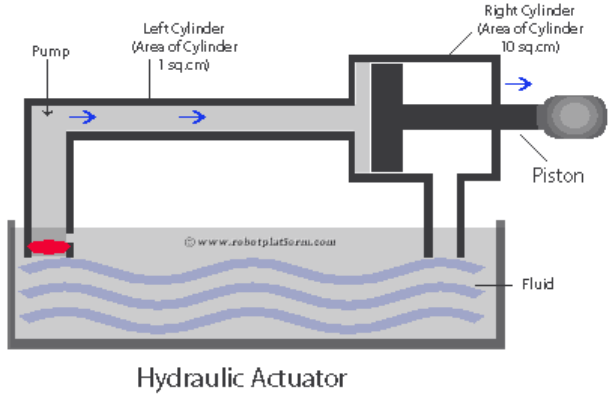
- An actuator is an electromechanical device which converts energy into motion.

Types of Robot Actuators:

- **DC Motors**
- **Pneumatic Actuator**
- **Hydraulic Actuator**





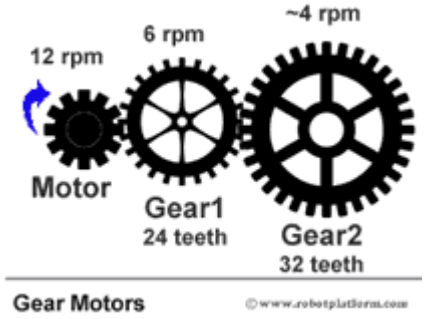


Main Components of Robots

5- Robot Actuators

Types of DC motors:

- **Brushed DC motor:** or simply a “DC motor”. It has a rotor and a stator with one of them being a permanent magnet. It is available in different sizes and different speeds. Although DC motors run at enough speeds, they are generally useless in robots as they produce the slightest torque. DC motors have only two wires running into them; one for ground and the other for power.
- **Geared DC motor:** To overcome the high speed and low torque of DC motors, they are often coupled with gears which provide greater torque, but reducing speed. Normally all our robots would require a geared DC motor to carry the weight of our robot and any additional components placed.



Main Components of Robots

5- Robot Actuators

Types of DC motors:

- **Brushless DC motor:** Brushless motors are very useful in robots as they can provide enough torque, and greater speeds than brushed motors. Brushless motors are expensive due to their design complexity and need a controller to control their speed and rotation.
- **Servo Motor:** These are DC motors coupled with a feedback control circuitry, a gear system to increase torque and a position sensing device (usually a potentiometer). When a signal (pulse) is sent, it moves the motor shaft to a desired position using the position feedback from a potentiometer. Servos do not exhibit continuous rotation, but are limited to a specific range (generally 180° back and forth). Since servos expect a control signal, there is an additional wire running into the servo which takes control pulses. Hence they have three wires; Ground, Power and Control pulse.

Main Components of Robots

5- Robot Actuators

Types of DC motors:

- **Stepper motor:** Stepper motors are brushless motors which divides the rotor’s rotation into discrete number of steps. The motor's position can be commanded to move and hold at one of these steps without any position sensor for feedback.

Main Components of Robots

6- Sensors

- Sensors are the power of a robot's feedback mechanism. They act like "eyes" and "ears" to help the robot take in information about its surroundings.
- Robots typically incorporate a wide range of sensor types to help them perform their work. These include:
  - Light sensors
  - Sound sensors
  - Temperature sensors
  - Contact sensors
  - Proximity sensors
  - Distance sensors
  - Pressure sensors
  - Positioning sensors

Main Components of Robots

6- Sensors

- **Contact and proximity sensors** help robots navigate safely, especially when deployed alongside human workers.
- **Pressure sensors** may control the grip strength of a powered robotic arm, so that it doesn’t crush the merchandise during it’s processing.
- **Positioning sensors** include GPS, digital magnetic compasses and other tools to approximate the location of a robot.
- Robots can navigate their surroundings through vision sensors, which function like eyes. Cameras feed in visual information, then an artificial intelligence (AI) process called machine vision analyzes the video footage to recognize objects, guiding the robot.

Main Components of Robots

7- Cameras

- For many robot applications, vision technology is not required. But there are a number of applications where it can be helpful. For example, picking and placing different objects, object detection, object classification, human-robot interaction, etc.

Camera types:

- RGB camera
- IR camera
- Depth camera

Main Components of Robots

8- Speakers

- Speakers are helpful in robots for applications like text-to-speech, chatting with robot or other people, speaking with warning/information messages, etc.

Speaker types:

- Wired speaker
- Bluetooth speaker


Any Questions