



Artificial Intelligence

COMP-241, Level-6

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Chapter 9: **Robotics**

In which agents are endowed with physical effectors with which to do mischief.

Robotics is physical agents that perform tasks by manipulating the physical world.

An automatic apparatus or device that performs functions ordinarily ascribed to humans or operates with what appears to be almost human intelligence.

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.

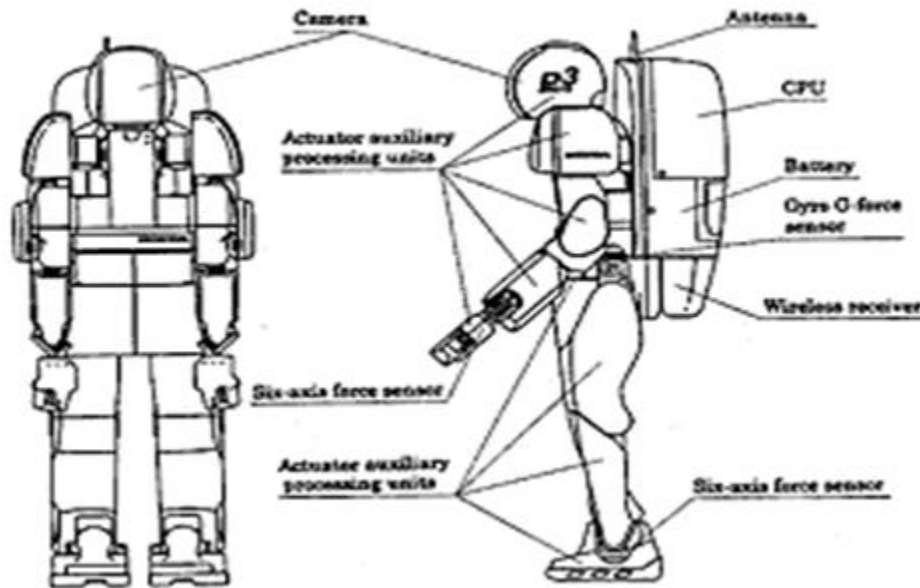
A robot is a machine that gathers information about its environment (senses) and uses that information (thinks) to follow instructions to do work (acts).

The robot is a computer-controlled device that combines the technology of digital computers with the technology of servo-control of articulated chains. It should be easily reprogrammed to perform a variety of tasks, and must have sensors that enable it to react and adapt to changing conditions. Most industrial robots satisfy this definition. They basically serve to eliminate the need of high cost, specialized equipment in the manufacturing industry.

A robot must have the following essential characteristics:

- **Mobility:** It possesses some form of mobility.
- **Programmability:** implying computational or symbol- manipulative capabilities that a designer can combine as desired (a robot is a computer). It can be programmed to accomplish a large variety of tasks. After being programmed, it operates automatically.
- **Sensors:** on or around the device that are able to sense the environment and give useful feedback to the device
- **Mechanical capability:** enabling it to act on its environment rather than merely function as a data processing or computational device (a robot is a machine); and

- **Flexibility:** it can operate using a range of programs and manipulates and transport materials in a variety of ways.



Robotics can do following things:

1. Sensing
2. Acting
3. Thinking

Effectors

Legs, wheels, joints, and grippers. Effectors have a single purpose to assert physical forces on the environment.

Sensors

Robots are also equipped with sensors.

There are three categories / types of robots:

1. Industrial Robot

An **industrial robot** is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing.

2. Mobile Robot

Mobile robots have the capability to move around in their environment and are not fixed to one physical location. In contrast, industrial robots usually consist of a jointed arm (multi-linked manipulator) and gripper assembly (or end effector) that is attached to a fixed surface.

Mobile robots are the focus of a great deal of current research and almost every major university has one or more labs that focus on mobile robot research. Mobile robots are also found in industry, military and security environments. They also appear as consumer products, for entertainment or to perform certain tasks like vacuum.

3. Hybrid Robot

A **hybrid** is a cybernetic organism in the form of a robot controlled by a computer consisting of both electronic and biological elements. The biological elements are typically rat neurons connected to a computer chip.

Actuators

Actuator is a control line that communicates a command to effectors.

Sensors

Sensors are the perceptual interface between robots and their environments.

Passive sensors

For instance – camera for true observers of the environment. This capture signals that are generated by other sources in the environment.

Active sensors

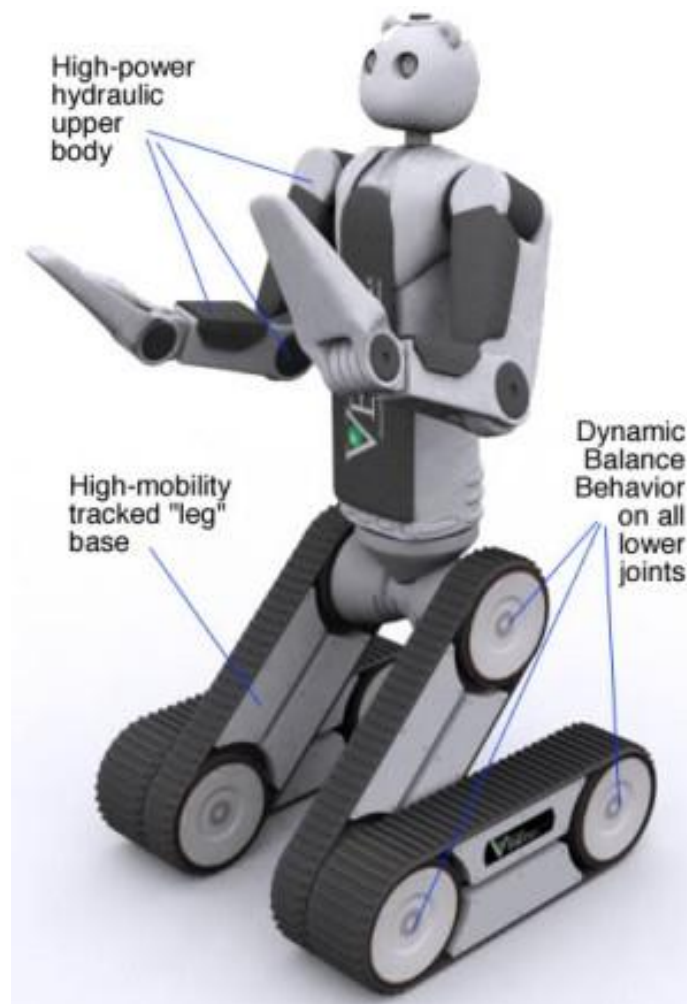
1. For instance sonar, send energy into the environment. This is fact that the energy is reflected back to the sensor. Active sensors tend to provide more information than passive sensors.
2. That the expense of increased power consumption and with a danger of interference when multiple active sensors are used at the same time.

Types of sensors:

1. Sonar Sensor
2. Tactile Sensors
3. Imaging Sensors
4. Proprioceptive Sensors
5. Force Sensors
6. Torque Sensors

Effectors

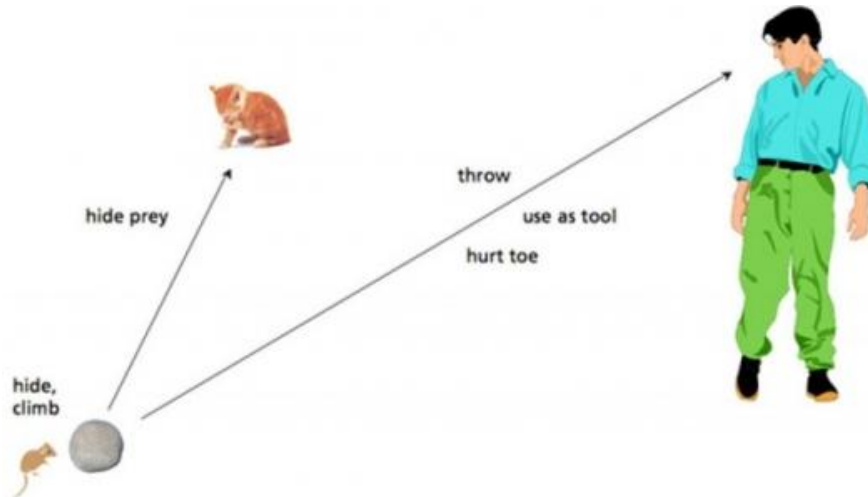
This means that the robots move and change the shape of their bodies.



Degree of freedom (DOF):

Robotic Perception

This is the process by which robots map sensor measurements into internal representations of the environment. Perception is difficult because in general the sensors are noisy, and the environment is partially observable, unpredictable and often dynamic.



Robotic properties:

1. They contain enough information for the robot to make the right decisions.
2. They are structured so that they can be updated efficiently and
3. They are natural in the sense that internal variables correspond to natural state variables in the physical world.

Types of motion:

1. Point-to-point motion
2. Complaint motion
3. Configuration space
4. Path planning
5. Cell decomposition
6. Skeletonization



Point-to-point motion

This problem is to deliver the robot or its end-effector to a designated target location.

Complaint motion

A greater challenge is the complaint motion problem, in which a robot moves while being in physical contact with an obstacle.

Path planning

This problem is to find a path from one configuration to another in configuration space.

The primary characteristic of path planning is that it involves continuous spaces.

Configuration space

The first step towards a solution to the robot motion problem is to devise an appropriate problem representation.

Moving

Till now, we have talked about how to plan motions, but not about how to move.

Robotic Software Architecture

There are following points for robotics software architecture:

1. A methodology for structuring algorithms is called software architecture.
2. Architecture usually includes languages and tools for writing programs.
3. Modern day software architectures for robotics must decide how to combine reactive control and model-based deliberative control.
4. In many ways, reactive and deliberate control shaves orthogonal strengths and weakness.
5. Reactive control is sensor-driven and appropriate for making low-level decisions in real time.
6. Most robot architectures use reactive techniques at the lower levels of control with deliberate techniques at the higher levels.

Hybrid Architectures

Architectures that combine reactive and deliberate techniques are called hybrid architectures.

Subsumption Architecture

This is a frame work for assembling reactive controllers out of finite state machines. Nodes in these machines may contain tests for certain sensors variables, in which case the execution trace of a finite state machine is conditioned on the outcome of such a test.

Three-layer Architecture

Hybrid architectures combine reaction with deliberation. By far the most popular hybrid architecture is the three-layer architecture.

This consists of three layer:

1. Reactive layer
2. Executive layer
3. Deliberate layer

Reactive layer

1. This provides low level control to the robot. It is characterized by a tight sensor-action loop.
2. Its decision cycle is often on the order of milliseconds.

Executive layer

1. This serves as the glue between the reactive and the deliberate layer.
2. It accepts directives by the deliberate layer and sequences them for the reactive layer.

Deliberate layer

1. This generates global solutions to complex tasks using planning.
2. Because of the computational complexity involved in generating such solutions, its decision cycle is often in the order of minutes.
3. The deliberate layer uses models for decision making.

Robotic programming languages

There are following languages have to support for robotic programming languages:

1. Lisp
2. Prolog
3. GRL – generic robot language
4. C
5. RAPS – Reactive action plan system
6. GOLOG
7. CES – C++ for embedded systems, this is a extension of C++
8. ALISP – This is an extension of Lisp.
9. Python

Application of Robotics

The need for industrial robots (for manufacturing automation) appears to be primarily driven by the shortage of labor and the cost of labor. While only Japan has embraced robotics in a big way, it would appear that it is only a matter of time before other industrialized nations follow suit. However, there are applications in hostile environments in which it is necessary to use robots (for example, in space, nuclear plants) or it is too dangerous to use humans (for example, military operations). There are others where the physical task demands skills that humans simply do not have (for example, surgery).

Some of these are briefly described here.:

1. Space Robotics

Space exploration needs human intelligence but does not need the physical presence of human bodies. In principle, human operators on earth can control partially autonomous vehicles and manipulators on the Moon, or on distant planets.

2. Hazardous Environments

DOE uses robotics technology for automating the manufacture of explosive components and for dismantling radioactive or toxic weaponry. The U.S. Navy is trying to use robotics technology for detecting and defusing mines in shallow water. A remotely controlled underwater submersible was used when the *Titanic* was salvaged several years ago.

3. Virtual reality

Virtual reality systems (simulators) can be used for training and educating people. An important component of these systems is the haptic interface, that allows the user/operator to feel the virtual environment and exert forces on it. Thus a virtual reality system is robot plus high resolution displays.

4. Highways

Cars are being equipped with increasingly sophisticated sensors, navigation systems and controllers. The IVHS project is aimed at building an intelligent highway system in which operations such as merge, change-lane and exit can be automated so that the human driver acts only in a supervisory mode. Highway maintenance and construction are also areas where robotic systems can be used for automation.

5. Medical Robots

The U.S. pioneered research in this area. In robot-assisted surgery the surgeon directs the robot to make controlled, high-precision incisions with accuracy far better than a human surgeon can. The latest advance in laproscopic surgery involves inserting a microrobot through a small incision in the body and teleoperate it to perform surgery, suturing, etc. Now Japan and Europe have active research programs in this area.

6. Personal care for disabled people

There are many assistive devices for people with disabilities. Robots can be vocational assistants by operating as arms for paraplegics. They can be used to fetch papers or pick up the phone. In a home, they can be used to push open doors, get water from a faucet, and pick up trash from the floor. Since a human user controls the personal robot, the robot need only have very limited intelligence.

7. Entertainment

Entertainment robots are a fast growing market that is fueled by growth in theme parks. In Disney's theme parks, robots are used to create animated figures. Ford used a robot to advertise its new 1996 models. Virtual reality systems are also ready to take off.

8. Custodian robot

Cleaning public restrooms is a tedious and dirty job and best left to a robot. Since restrooms are fairly structured (most toilets, urinals and sinks look similar), the cleaning operation can be automated. In large public buildings such as airports and train stations, robot vacuum cleaners can be used to clean carpets.

9. Robot attendant at gas station

A robot system can be used to fill up the gas tank without getting out of the car. This would be a great benefit if it is very hot or cold outside or if it is very late at night.

1. Industry and agriculture
2. Transportation
3. Hazardous environments
4. Exploration
5. Health care
6. Personal services
7. Entertainment
8. Human augmentation

Text Reference:

Artificial Intelligence – A Modern Approach, Second edition, Stuart Russell & Peter Norvig

Exercises:

Q1. Define robots with a suitable example.

- a) Robot*
- b) Effector*
- c) Sensor*
- d) Actuator*

Q2. What are robots can do?

Q3. Explain the types of robots with an example.

Q4. Write the names of sensors with the help of robot.

Q5. Explain the degree of freedom.

Q6. Write the types of motions with the help of robot.

Q6. Explain the robotic software architecture.

Q7. Write the name of programming languages to develop robots.

Q8. Explain the applications of robots.

Q9. Explain the characteristics of robots.