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Cover page of Lecture Notes

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Name of Subject: **CIM**

Chapter/ Unit No.

Robotics

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Robotics In CIM

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Robots perform several tasks in factories.

- Movement of materials on the shop floor
  - (Automated guided vehicles (AGV) or rail guided vehicle (RGV)
- Loading and unloading of components in machines
  - (Gantry robot, machine mounted robot, free-standing robot)
- Inspection using vision sensors
- Manufacturing operations like
  - painting, welding, sorting, automatic assembly, sampling, dispensing, marking, etc.

Intro

- Robots are programmable machines with some human like capabilities.
- They are made up of mechanical components, a control system and a computer.
- These elements can be arranged in different ways and can vary in size and complexity to perform different tasks.
- Robots are controlled by a variety of hardware and software systems.
- The more complex tasks usually require servo-control systems, which use sensors and microprocessors.
- The control system carries out the functions, which govern the robot’s motion.

DEFINITION OF A ROBOT

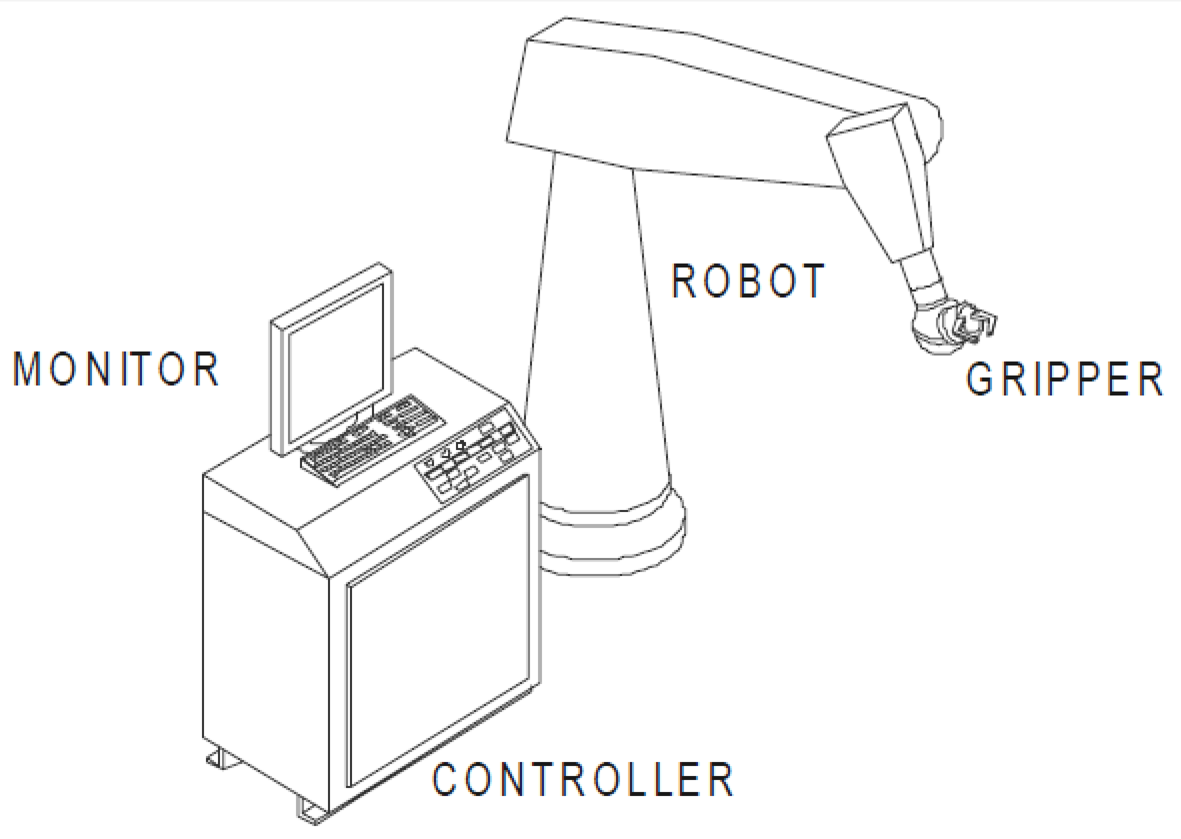
- In general robots can be defined as “Programmable and Automatic Manipulators”. It is a special type of computer-controlled machine that can perform a wide variety of tasks.
- The first is by Computer Aided Manufacturing-International (CAM-I), USA:
  – It states that a robot is “a device that performs functions ordinarily ascribed to human beings, or operates with what appears to be almost human intelligence.”

DEFINITION OF A ROBOT

- The second definition is by Robotics Institute of America (RIA), USA. RIA defines a robot as a
  - "programmable, multifunction manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks."

- The word “Robot” comes from the Czech word “Robota” which means “labor doing compulsory manual works without receiving any remuneration” or “to make things manually”.
- In fact, the term "robot" was first used in 1920 in a play called "R.U.R. (Rossum's universal robots)" by the Czech writer Karel Capek. The plot was simple: man makes robot then robot kills man! Many movies that followed continued to show robots as harmful, menacing machines.

ELEMENTS OF A ROBOTIC SYSTEM



Components of the robot manipulator:

- A manipulator (the base and arm assembly)
- End-of-arm tooling, such as a gripper or end effecter
- Actuators (motors or drives that move the links of the robot) and associated equipment
- Transmission elements like belts, pulleys, ball screws, gearing and other mechanical components.

Control system

- The control system is used to generate the necessary signals co-ordinate the movements of the robot. It includes:

  (a) Mechanical, hydraulic, pneumatic, electrical, or electronic (either open loop or closed loop) controls.

  (b) Sensors including cameras, amplifiers, and related hardware.

  (c) Equipment interfaces.

Computer system:

- This provides the data processing capability necessary to interpolate the intermediate positions and control the movement of the links or arms the robot. It includes:

  (a) Microprocessor or a programmable logic controller or a personal computer

  (b) User interfaces (e.g. keyboard, display, teach pendant)

  (c) Control software to manipulate the robot for various applications

Important benefits

TYPES OF ROBOTS

- Industrial robots are designed in a variety of shapes and sizes.
- They can be classified based on a few basic characteristic features.

(i) Movements along different axes

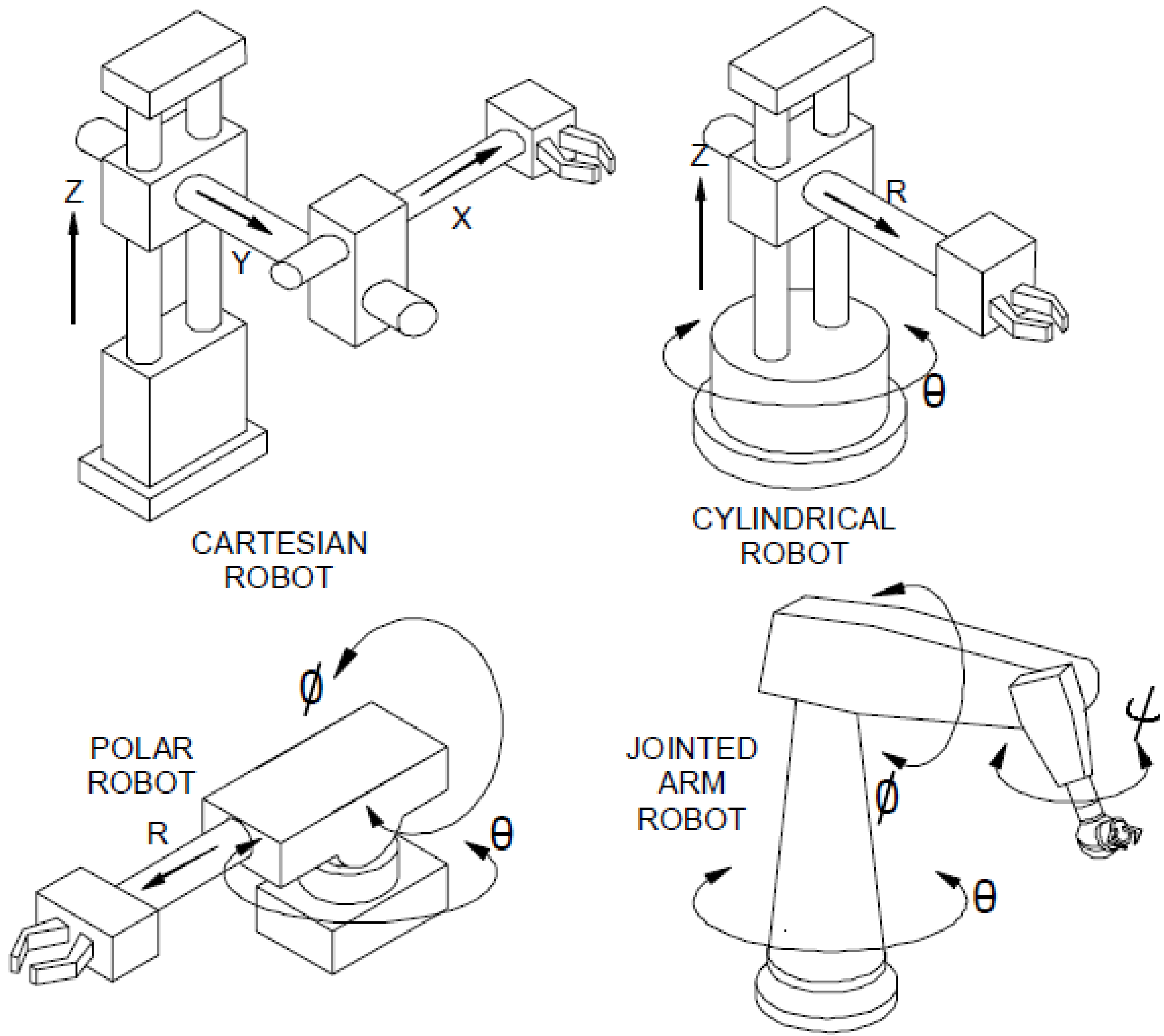
(ii) The complexity of the path in which the manipulator can move.

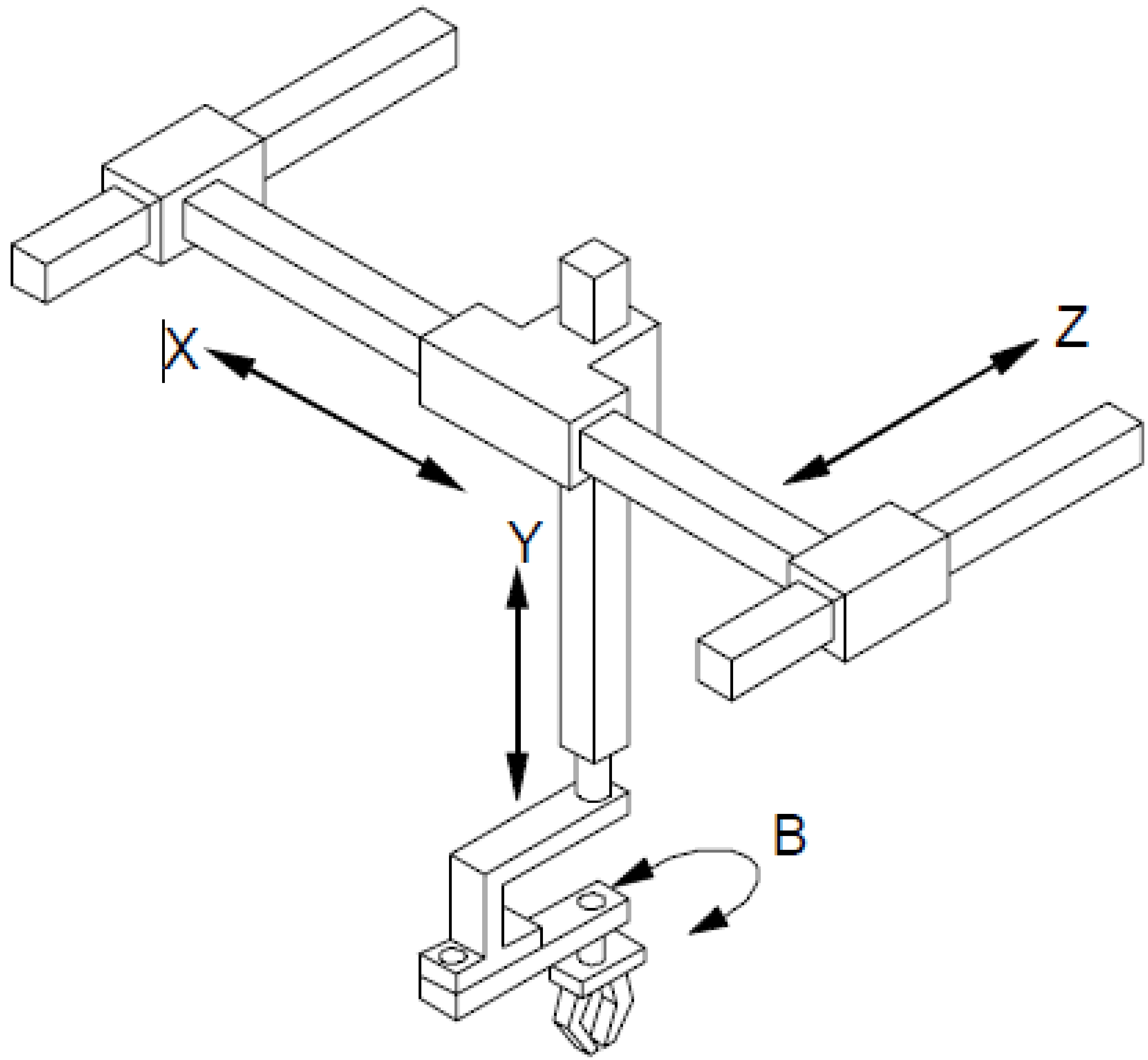
(iii) The type of power source used to move the manipulator. (Electrical, hydraulic, pneumatic etc.).

(iv) The techniques and systems used to control the motion of the manipulator. (Servo and non-servo).

(v) Depending on whether the robot is stationary or mobile.

CLASSIFICATION OF ROBOTS BASED ON MECHANICAL CONFIGURATION




X
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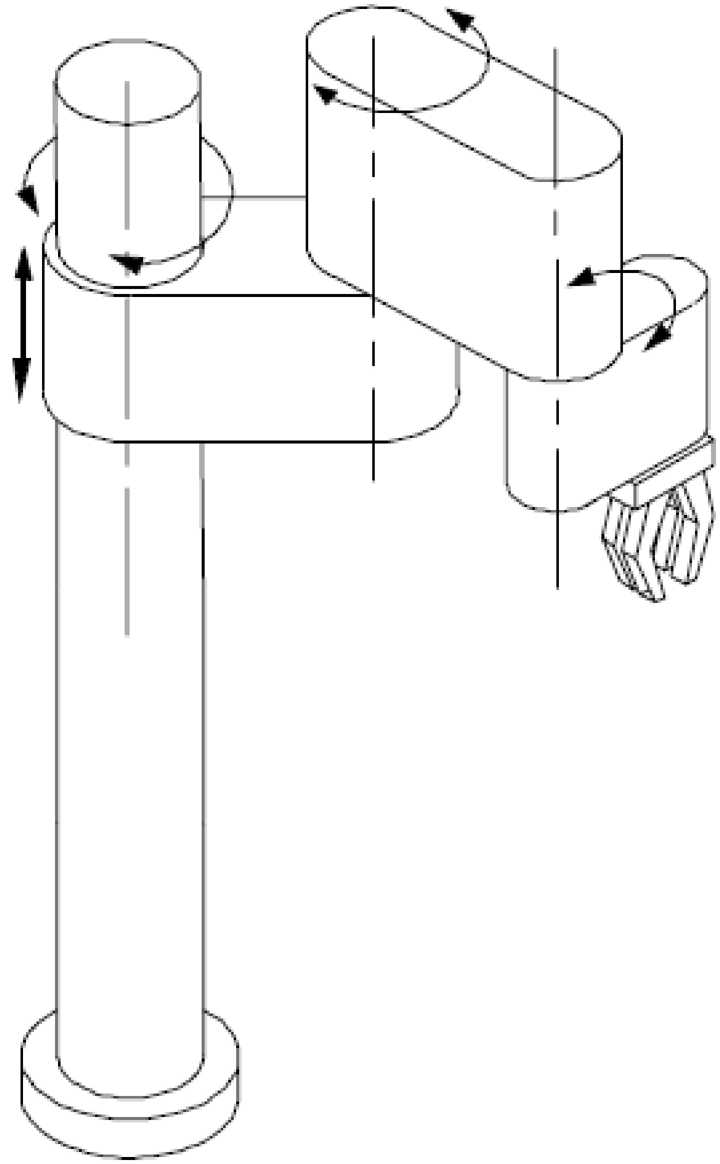
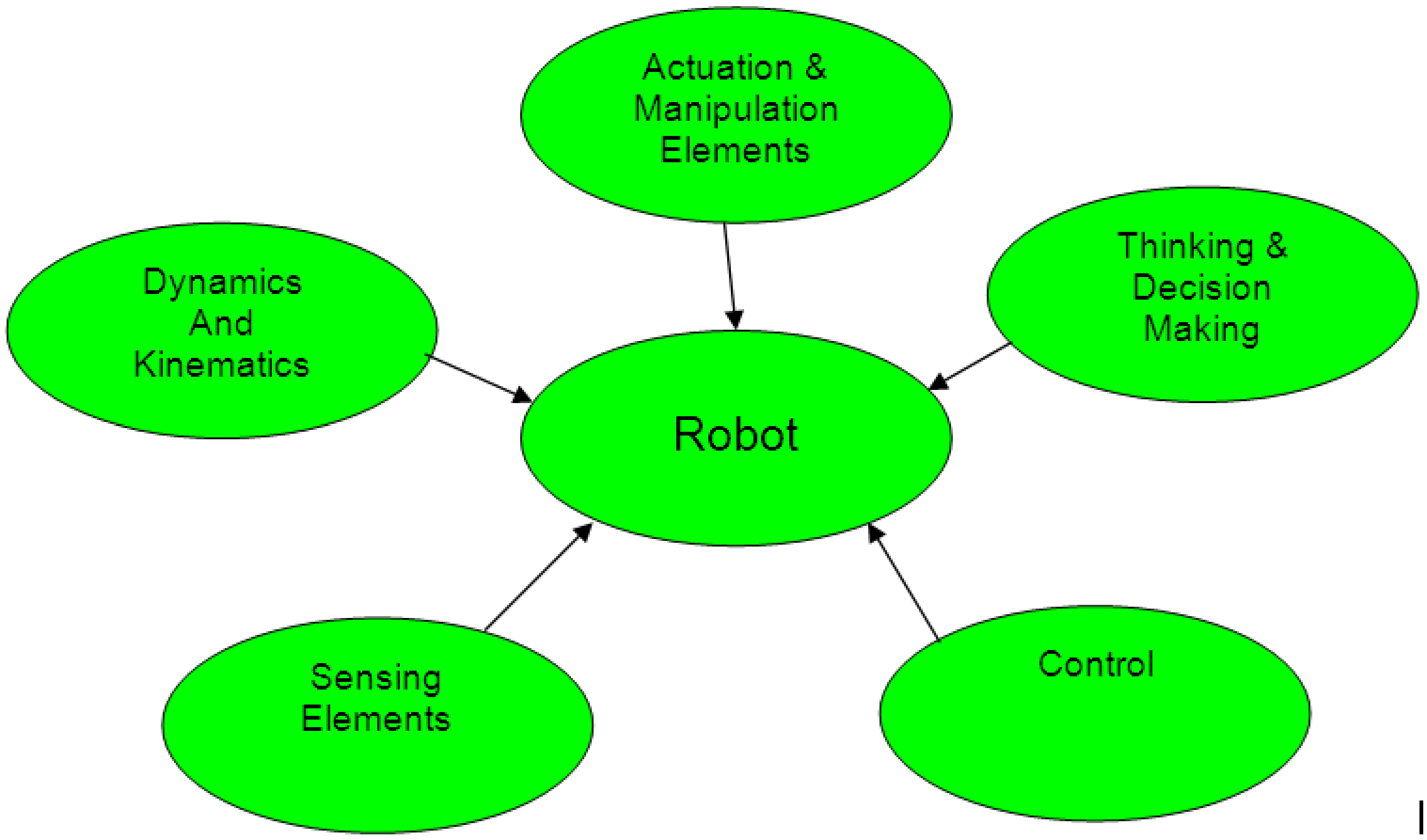


FREEDOM OF MOTION

- The number of axes it uses or independent moves it can make.

Issues in Robotics



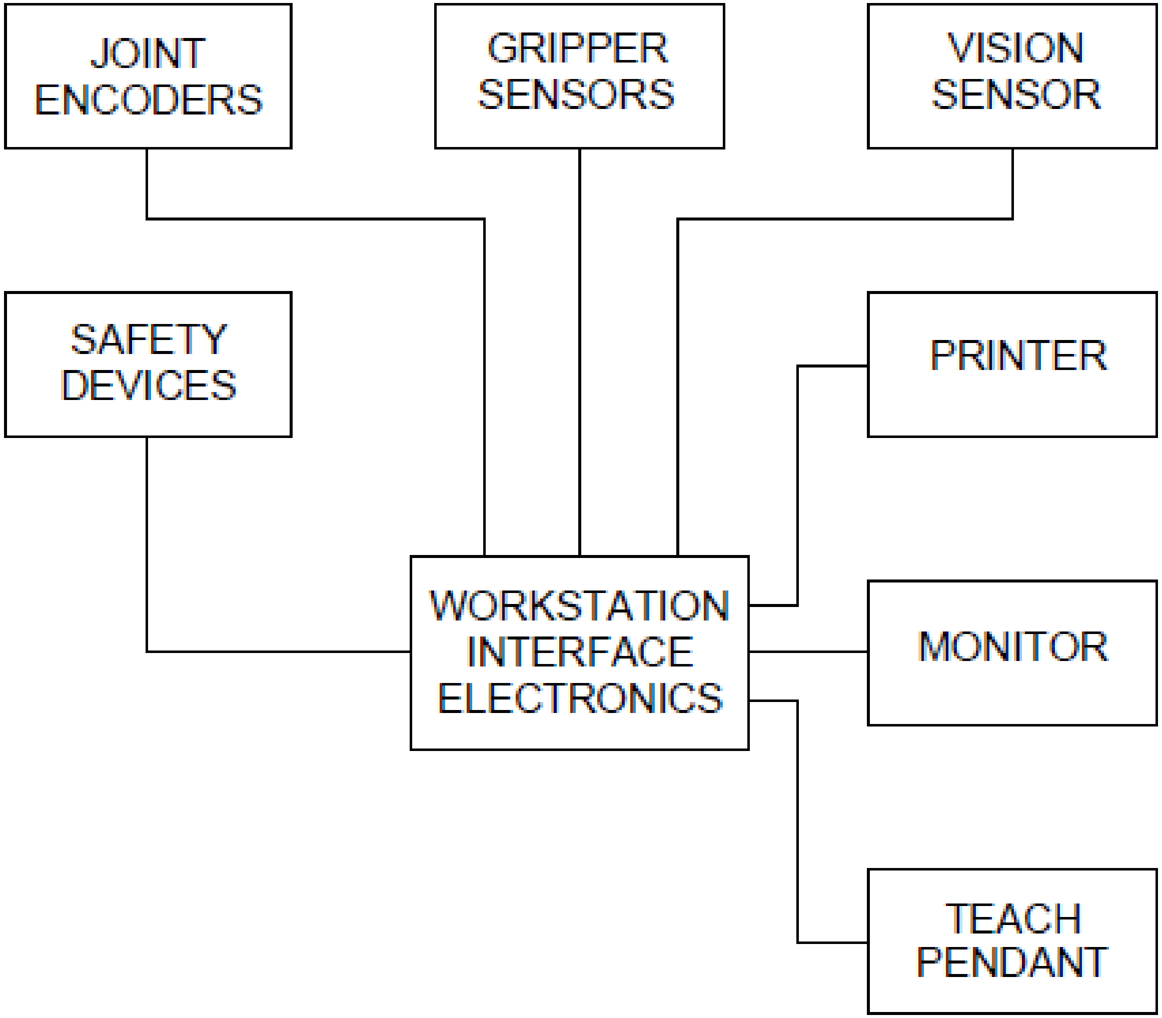
1. Actuation & manipulation Elements

Motors	Driving mechanisms	manipulation
DC motor AC motor Stepper motor Servomotors Piezo Motors	Gears and chains Pulleys and belts Gearboxes	Air Muscles Electro-active Polymers Grippers Vacuum Grippers General purpose effectors

3. Sensing Elements

- *light sensors*
- *camera "eye“*
- *ultrasonic sound*
- *Microphone*
- *Touch sensors*
- *Position sensors*
- *electromagnetic sensors*
- *Smell and taste*
- *infrared sensor*
- *bump and feeler sensor*

Control System of a Robot



Asimov's Three Laws of Robotics

- Scientist-turned-writer Isaac Asimov wrote many science fiction tales that featured robots as characters. In Asimov's stories, the robots were guided by a set of rules, called "The Three laws of Robotics," which prevented robots from harming people. They are:

1. **A robot may not injure a human being or, through inaction, allow a human being to come to harm.**
2. **A robot must obey the orders given to it by human beings, except where such orders would conflict with the first law.**
3. **A robot must protect its own existence, as long as this does not conflict with the first two laws.**

- Although Asimov wrote these laws as fiction in the 1940's, before robots existed, they reflect ongoing concerns that some people have about robots. Technically, destructive technologies like "smart" cruise missiles (which can be considered robots) are already violating Asimov's laws.

PERFORMANCE CAPABILITIES

- In general, a robot user would look for desirable characteristics such as high reliability, high speed, programmability, and low cost.
- 1. Axes of motion
- 2. Work envelope
- 3. Speed
- 4. Acceleration
- 5. Payload capacity
- 6. Accuracy
- 7. Resolution
- 8. Repeatability
- 9. Reliability

KEY FEATURE CAPABILITIES

- Quality
- Serviceability
- Safety
- Modularity
- Dexterity

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TECHNICAL SPECIFICATION OF A ROBOT

Typical specifications of a robot are given below:

No. of axes	6
Maximum reach	1 m
Payload	8 kgf
Repeatability	+ 0.025 mm
Joint speed	90 deg/sec
Waist rotation	290 deg
Shoulder rotation	300 deg
Elbow rotation	300 deg
Wrist pitch	+ 90 deg
Wrist roll	+ 180 deg
Drive	AC Servomotor
Mounting options	Pedestal, table top, floor, overhead, servo track

Controller specifications:

Processor	32 bit
Memory	10 MB
Communication	RS 232 Serial ports
User I/O	32 digital I/O
24 analog I/O	
Programming Language	AR-SMART, AR-BASIC

PROGRAMMING METHOD

- Guiding
  - This is also known as the “Walk through” or “Playback” method. It involves manipulating the robot arm so that it can be moved manually through the intended motions while its link movements are being recorded by the control system.

- Teach pendant
  - This is also known as the “lead through” method. It uses a control panel, called a “teach pendant”, which has buttons or switches that control the motion of the robot. The operator or programmer can lead the manipulator through the task one step at a time, recording each incremental move along the way.

- Off-line programming
  - This is the most common method of robot programming in which a high-level language is used to write a control program. This program describes all the movements and actions of each of the links of the robot. The program may involve many steps, requiring a large number of lines of program code.
  - This method of control is the most flexible and can also enable the robot to respond to signals from external sensors to modify its movements.

- On-line programming
  - This requires the availability of a robot, but it also gives the programmer the ability to see the motions of the robot actually executing the program as it is being developed.
  - In most cases, this approach is used either as a substitute for a teach pendant or to debug programs that have been written off-line.

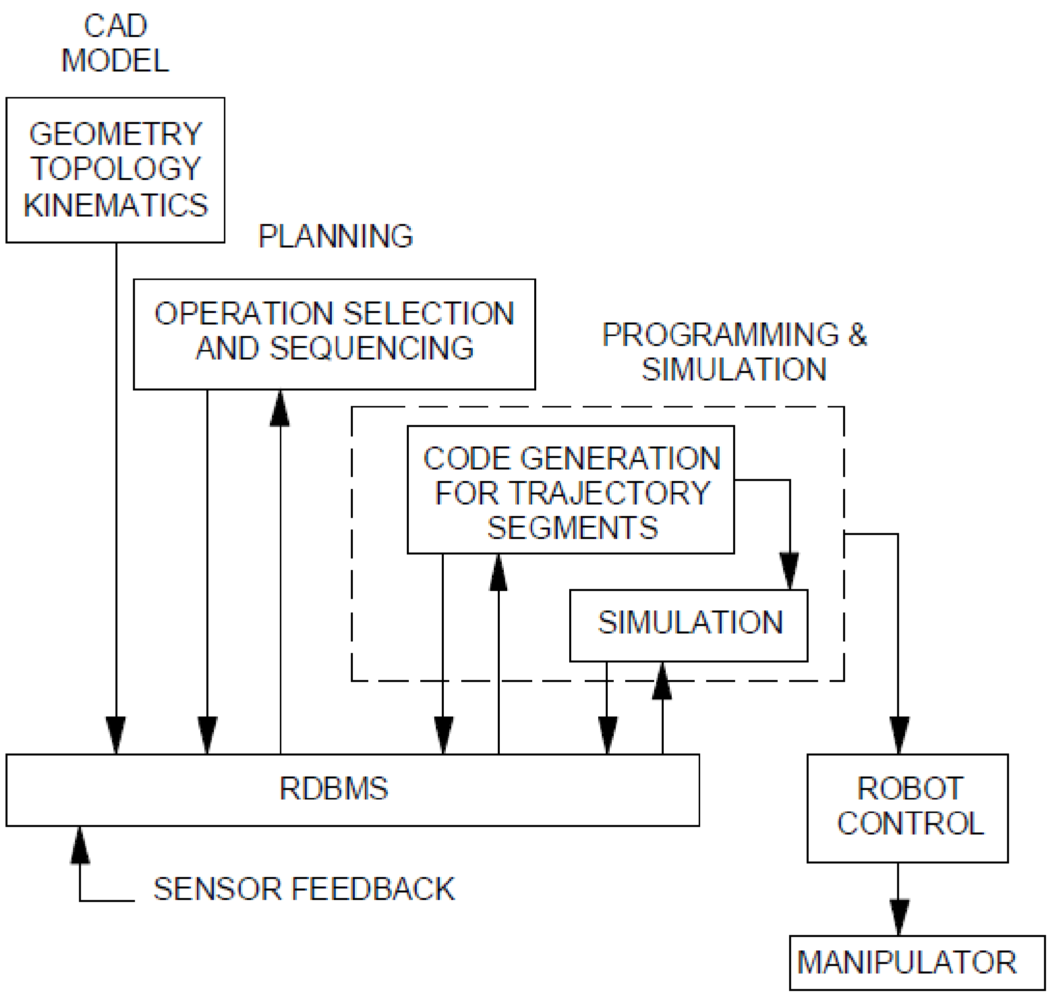
Comparison of off-line and on-line programming

- On-line and off-line programming are used on different control levels of the robot cell.
- Off-line programming supports the integration of robots into a CIM system.
- It allows the manipulation of CAD system data to reduce the programming time by eliminating the interaction with the physical devices.
- The programming method, however, has difficulty in handling sensor information, and this obliges the programmer to use simulation, which allows modeling of the sensor input in critical situations and its interpretation.

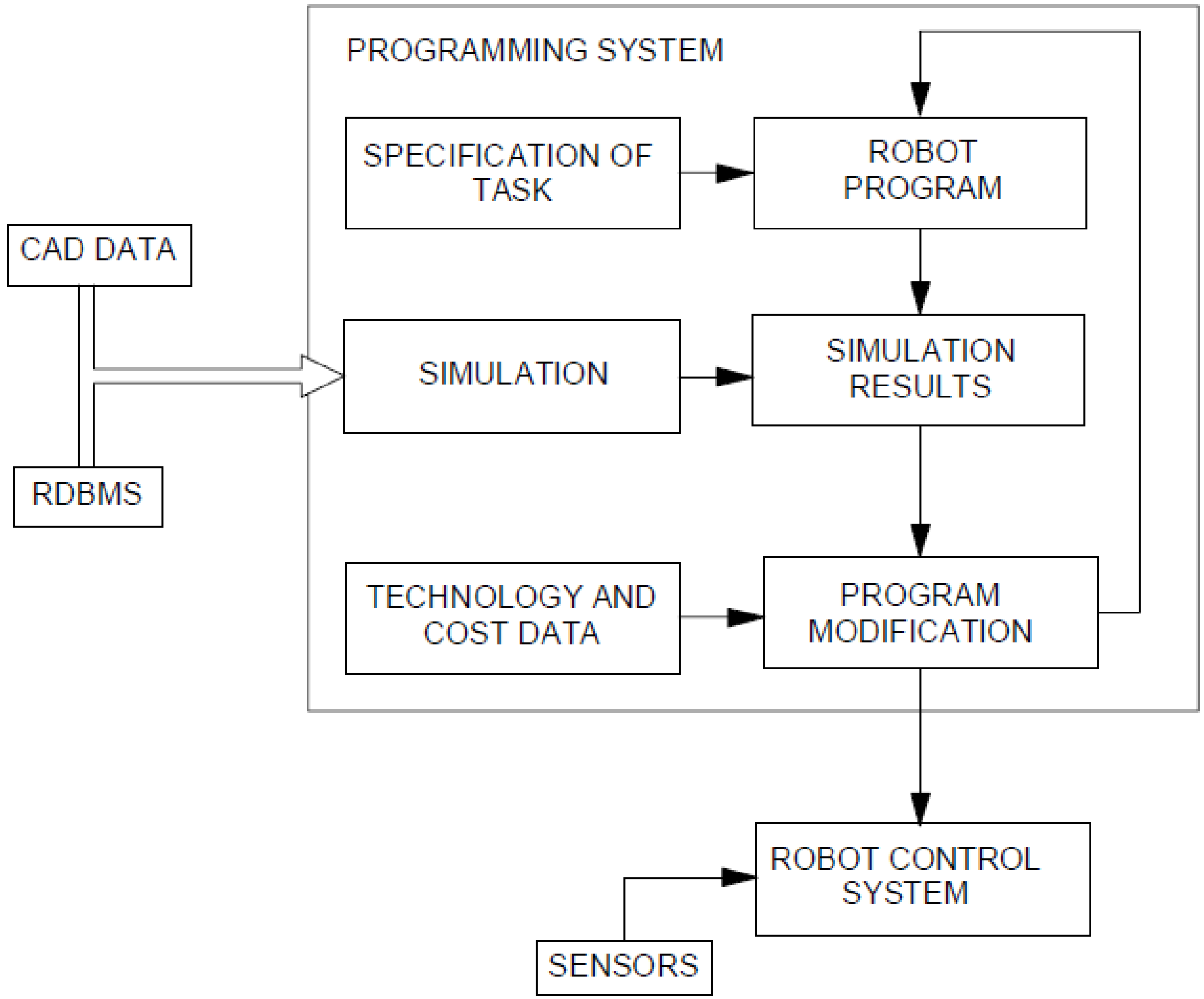
Comparison of off-line and on-line programming

- In general, an off-line programming system needs a software development environment to specify the application requirements, to analyze the
- tasks, and to decompose the global task to subtasks. Program test facilities are needed, as well.
- An on-line programming system provides tools for debugging and testing the program.
- Here the use of the physical robot system is required.
- An on-line language is more convenient to non-expert users.

Structure of an Off-line Programming System



Block Diagram for Off-line Programming



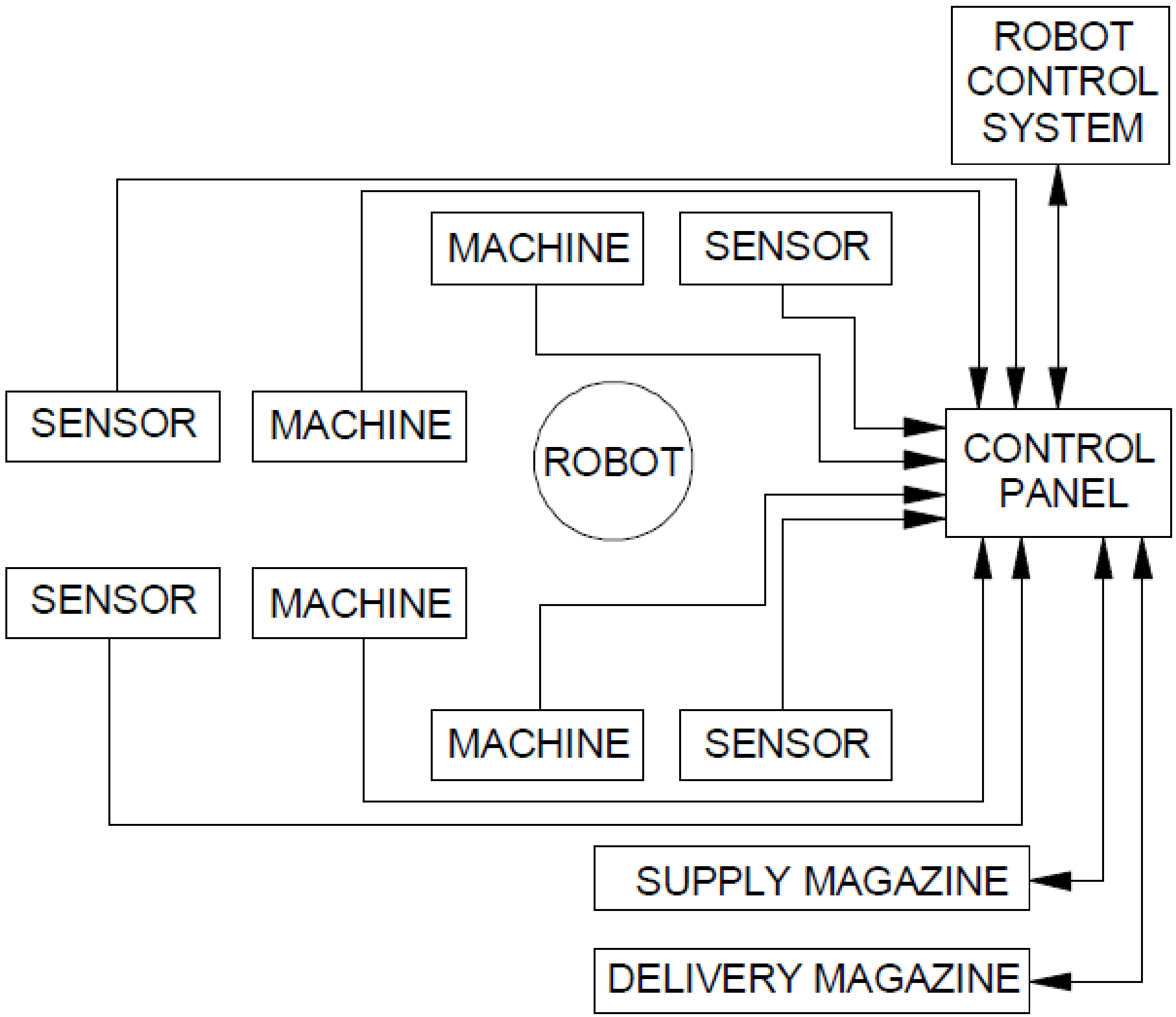
BASIC TYPES OF ROBOT PROGRAMMING LANGUAGES

- Point-to-point motion languages
- Basic motion languages at the assembler level
- Non-structured high level programming languages
- Structured high level programming languages
- Numerical control type programming languages
- Object-oriented languages
- Task-oriented languages

APPLICATIONS OF INDUSTRIAL ROBOTS

Application	*USA*	*JAPAN*
Welding	35%	28.5 %
Material	26%	27.5 %
Handling/Casting	8 %	9 %
Machine Loading	5 %	3.5 %
Painting Assembly	16 %	26 %
Others	10%	5.5 %

Block Diagram of an Industrial Robotic Cell



MANUFACTURERS OF ROBOTS

- Fanuc
- Kuka
- ABB
- Epson
- DENSO
- Hyundai
- Comau
- Nachi
- Motoman
- Adept
- ABB
- Seiko
- Kawasaki
- Staubli Unimation
- Mitsubishi

Where Robots are Applicable?

Space

Space Robotics is the development of machines for the space environment that perform Exploration, or to Assemble / Construct, Maintain, or Service other hardware in Space.

e.g. Space Shuttle robotic arm, Mars Exploration Rovers, etc.

Medical

We can use robots in medical field for operation of machines. We can use the robot in medical for different medical testing.

It can be used for endoscopies, Radiology, laparoscopy etc.

In present the robot is used as medical bullet.

Construction Field

In construction, the robot is very helpful.

In construction robot-arms are used to make blocks and also for work load.

e.g., In construction of big buildings.

Mechanical Field

In mechanical field, the robot is used in production.

e.g., Motor production, Ceramic factories, etc.

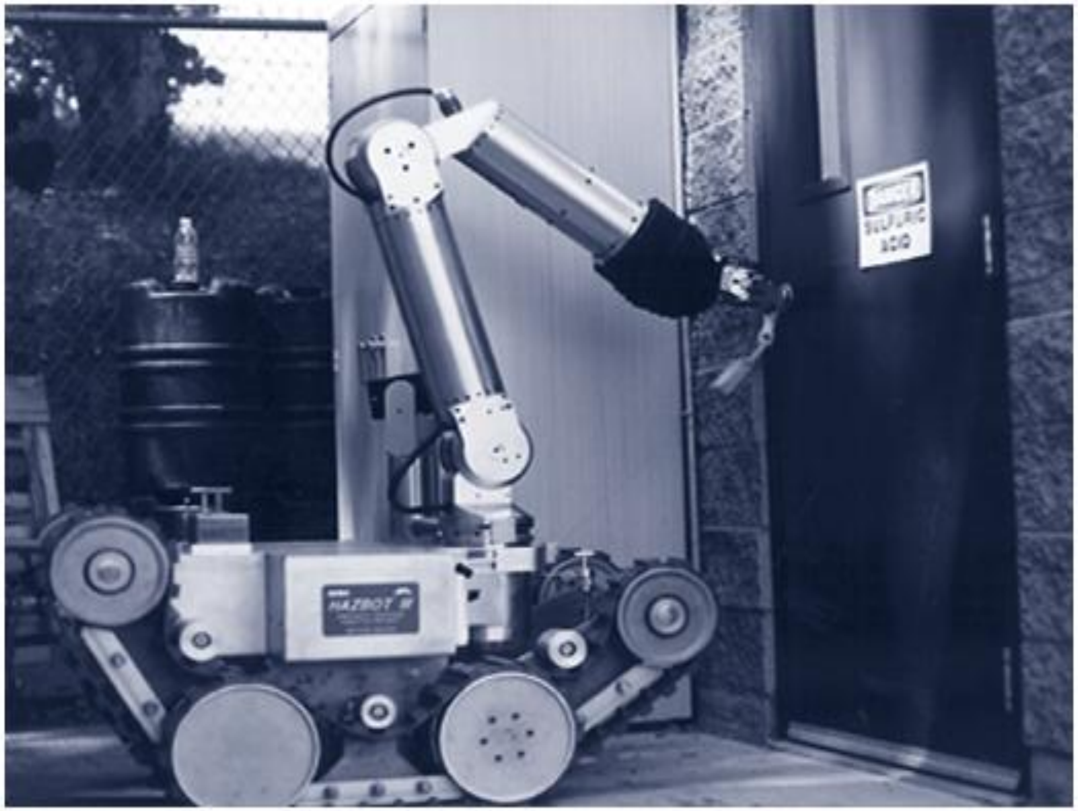
Welding

The robot is also for welding Purpose.

e.g., Laser Welding, Plasma Welding etc..

Education

Now in days, robot used for education purpose. In present the robots work as teacher are also available.



Automatic Control

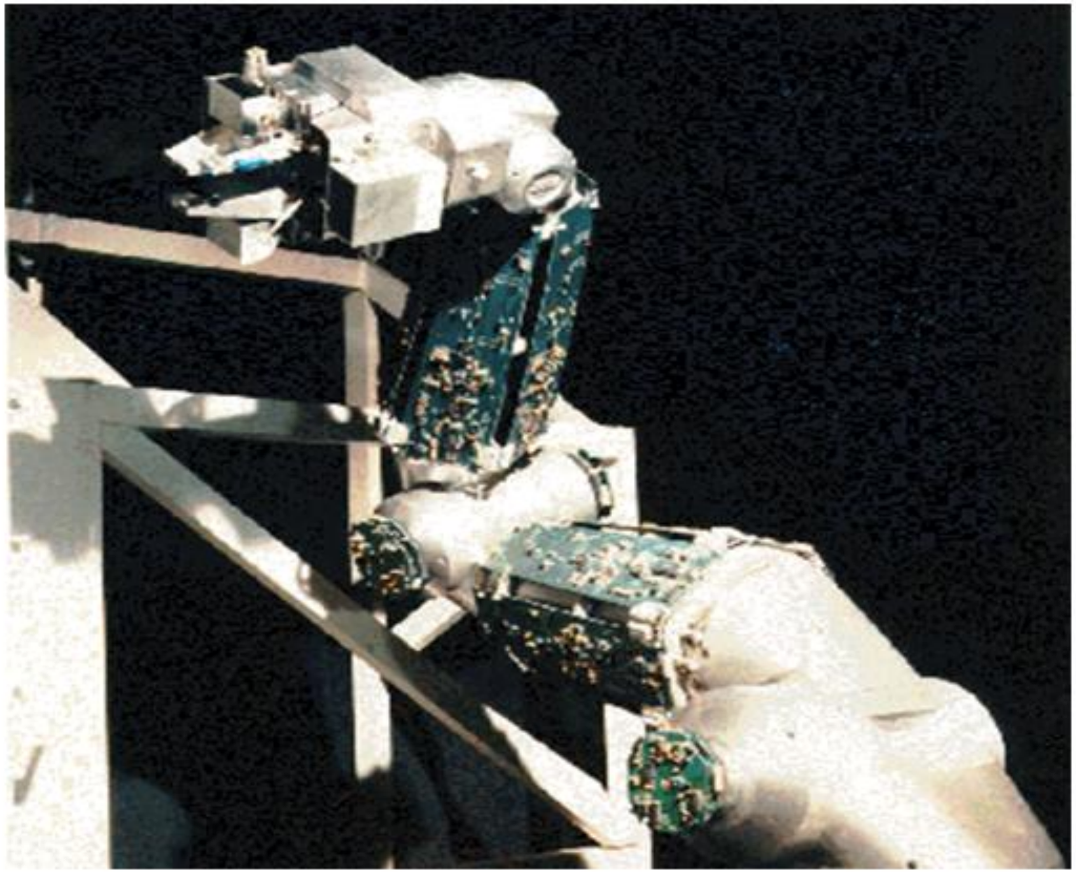
In different industries, Robot is used for automatic control of machines.

e.g., In pharmaceutical companies, pipe production companies, etc.

Work-shop

In work-shop, the robot is used machining operation.

e.g., operation of crane, for machining process etc.



Automobile Industry

All of the automobile companies use robot for automobile production.

e.g., in car production unit etc.

Human Comfort

Now in days, some of the people use robot for security, as servant, for enjoyment etc.

e.g., security dog, Dancing robots etc.

Defense

In present, the robot is used for different operations in Air-force, Military, and also in Navy.

e.g., Anti-terrorism Robot etc.

Questions Please

Thanks

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