ATME College of Engineering

CAD/CAM 18ME72

Module-3
Robotics

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Chapter 5

Robotics

Definition

An industrial robot is a programmable, multi-functional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks.

Robotics is a multidisciplinary engineering field dedicated to the development of autonomous devices, including manipulators and mobile vehicles

It ideally suited to a variety of production tasks, including machine loading, spot welding, spray painting and assembly.

Robot Anatomy :

An industrial robot consists of a mechanical manipulator and a controller to move it and perform other related functions

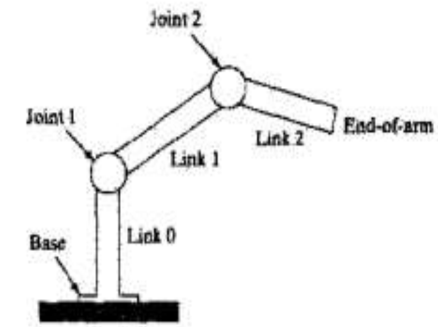
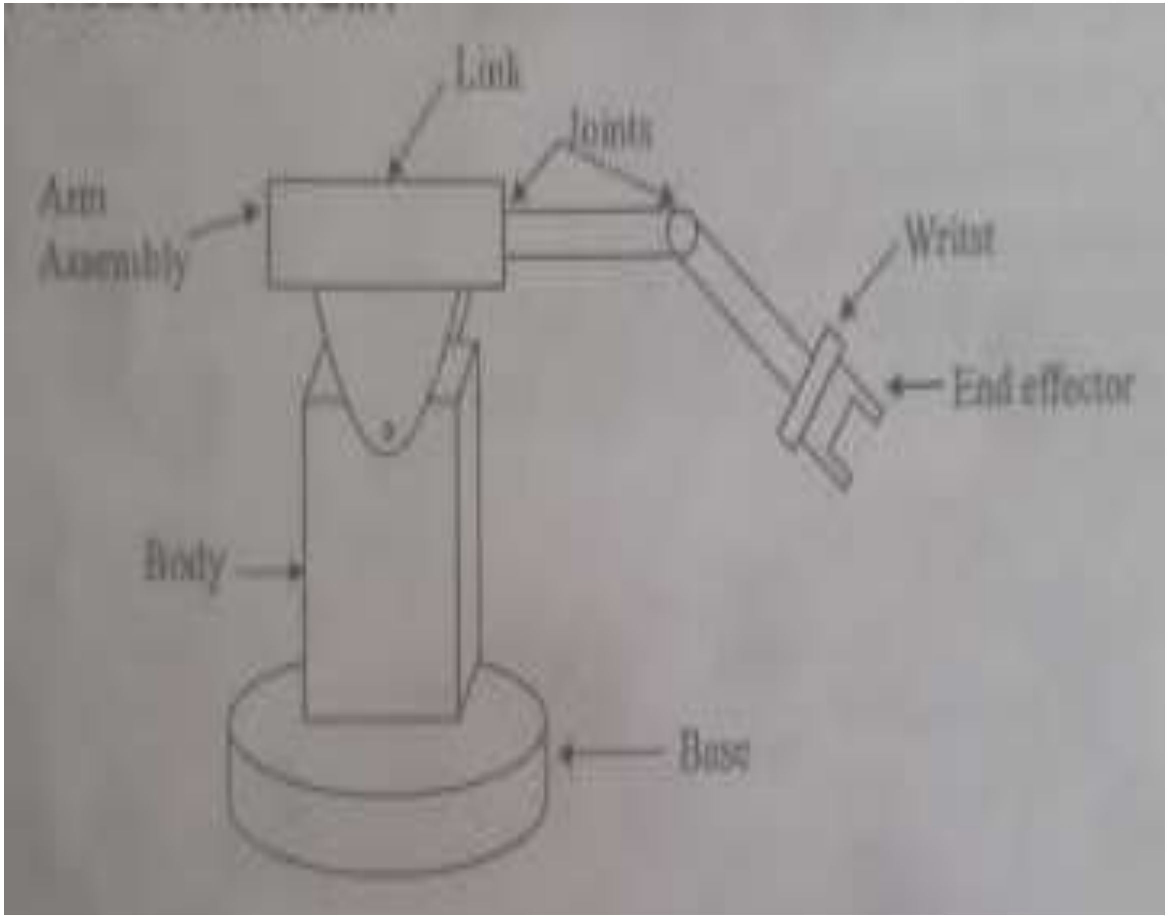


Figure 7.1 Diagram of robot construction showing how a robot is made up of a series of joint-link combinations.

- The mechanical manipulator consists of joints and links to position and orient the end of the manipulator relative to its base
- The controller operates the joints in a coordinated fashion to execute a programmed work cycle
- A robot joint is similar to a human body joint It provides relative movement between two parts of the body
- Typical industrial robots have five or six joints, Manipulator joints classified as linear or rotating

Robot anatomy



ROBOTS Advantages:

l . Environmental Safety.

2. Suitable for Hazardous (or) Uncomfortable working conditions

3. Performs repetitive tasks.

4. Low material usage.

5. Can operate for longer periods.

6. Robots can perform the operations with a very high accuracy

Disadvantages :

l . Initial investment cost is high.

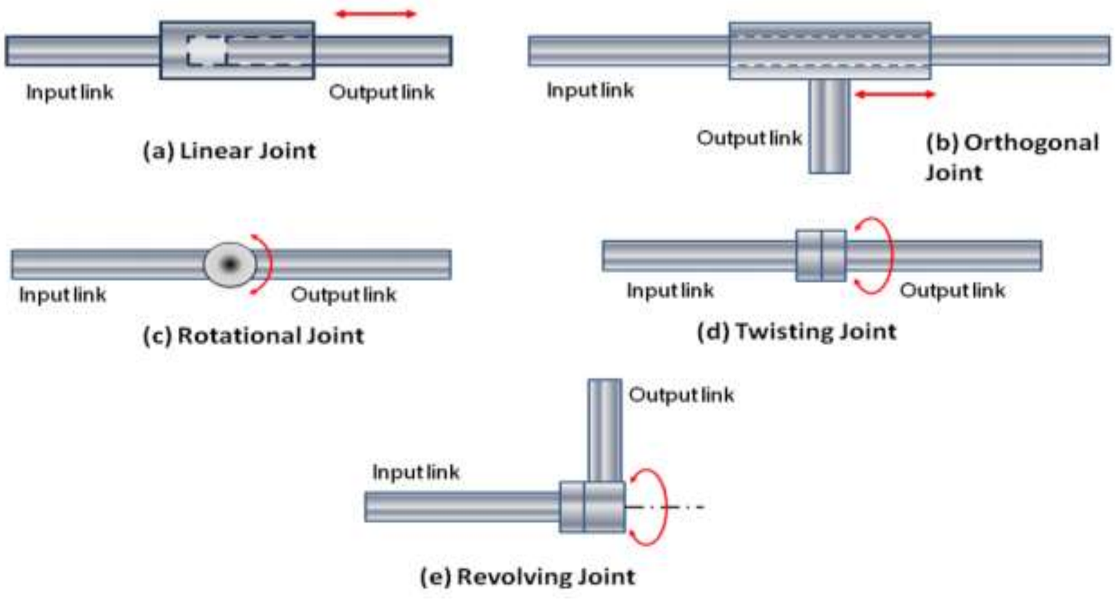
2. Cannot make decisions.

3. Cannot adapt changes automatically.

4. Cannot learn from Experience.

Robot Joints :

- Linear joint (type L)
- Orthogonal joint (type O)
- Rotary motion Rotational joint (type R)
- Twisting joint (type T)
- Revolving joint (type V)



Robot Physical Configuration

Industrial robots come in a variety of shapes and sizes. They are capable of various arm manipulations and they possess different motion systems.

1.Cartesian configuration: A robot which is constructed around this configuration consists of three orthogonal slides, as shown in fig. the three slides are parallel to the x,y,and z axes of the Cartesian coordinate system

2. Cylindrical configuration: In this configuration, the robot body.

Is a vertical column that swivel about vertical axes.The arm consists of several orthogonal slides

3. Polar configuration: this configuration also goes by the name "spherical coordinate" because the workspace within which it can move its arm is a partial sphere as shown in figure. The robot has a rotary base and a pivot that can be used to raise and lower telescoping arm

4. Jointed-arm configuration: is combination of cylindrical and articulated configurations. This is similar in appearance to the human arm, as shown in fig. the arm consists of several straight members connected by joints which are analogous to the human shoulder, elbow, and wrist.

Physical configuration may be described Notation

Robotic Configuration (Arm & Body)	Symbol
Cartesian Configuration	LLL
Cylindrical Configuration	TLL,LTL,LVL
Polar Configuration	TRL
Jointed Arm Configuration	TRR,VRR
SCARA Configuration	TRR,VRR

Robot Configuration

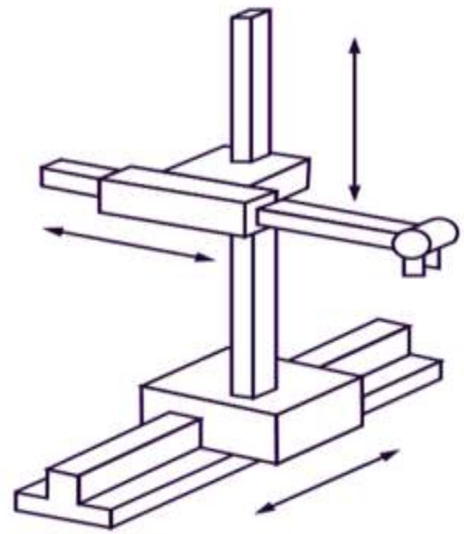
Cartesian Configuration

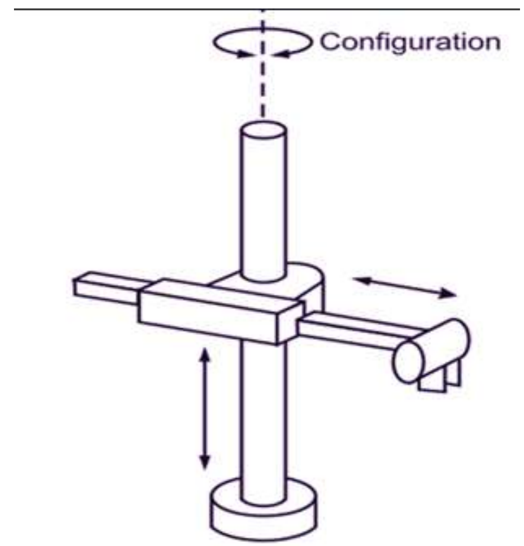
Cylindrical Configuration

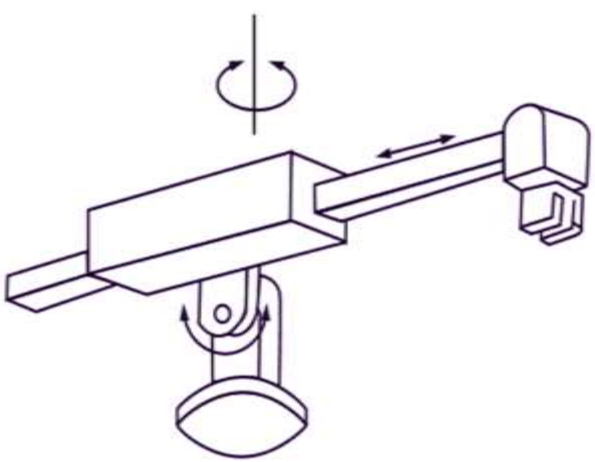
Polar Configuration

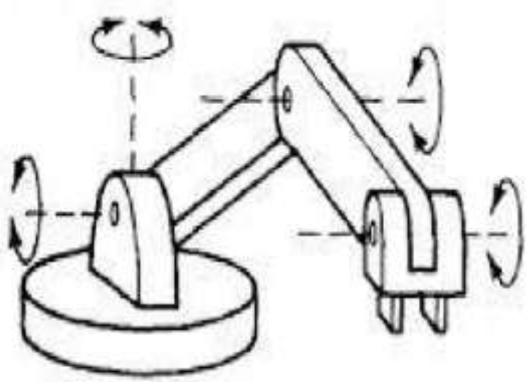
Jointed arm Configuration

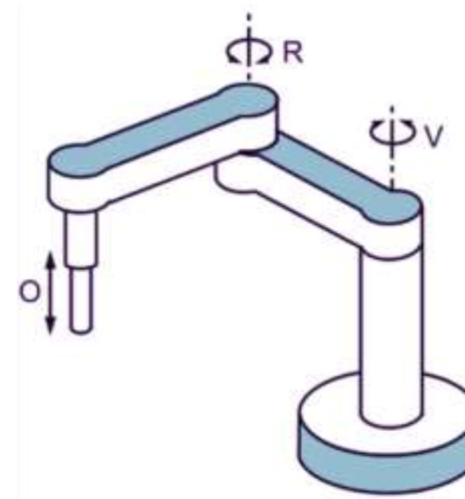
SCARA Robot

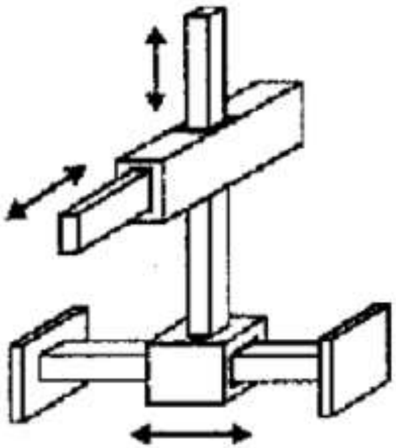




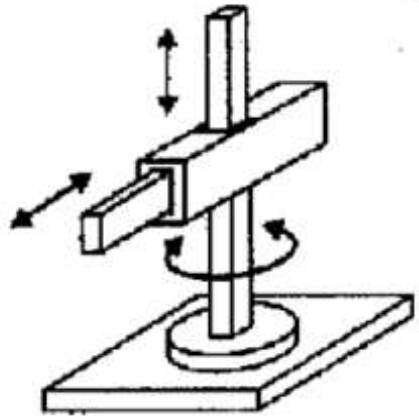




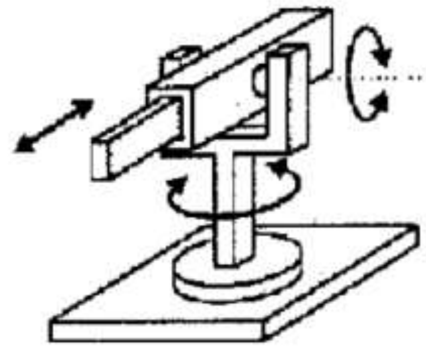




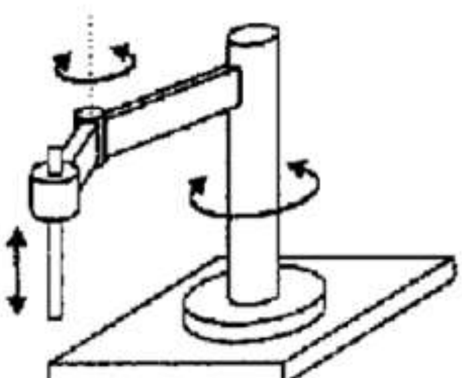
Cartesian Robot



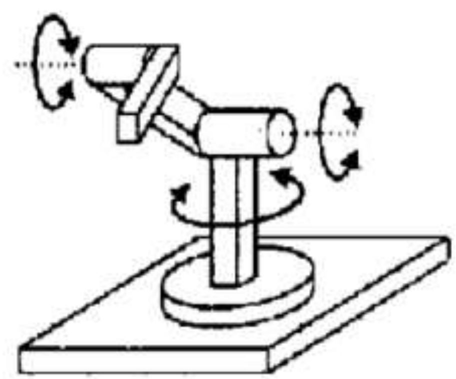
Cylindric Robot



Polar or spheric Robot



SCARA Robot



Angular or anthropomophic Robot

Basic Robot Configurations

The purpose of the robot is to perform a useful task. To accomplish the task, an end effector, or hand, is attached to the end of the robots arm. It is the end effector which adapts the general purpose robot to a particular task. To do the task, the robot arm must be capable of moving the end effectors through a sequence of motions and positions.

Vertical traverse: Up and down motion of the arm, caused by pivoting the entire arm about a horizontal axis or moving the arm along a vertical slide

Radial traverse: extension and retraction of the arm (in and out movement)

Rotational traverse: rotation about the vertical axis (right or)

left swivel of the robot arm

Robot Specifications

Characteristics which are used to specify Robots are

1.Number of Axes

2.Capacity

3.Speed

4.Reach and stroke

5.Operating Environment

6.Performance Parameters

1.Number of Axes :This specifies the number of independent degrees of freedom that (each part of the robot) wrist end can manipulate

2.Capacity : It refers to the load carrying capacity of the Robots

Higher the load carrying capacity lower the accuracy.It depends on the type of drive system used.

3.Speed : It refers to the distance moved by the tool in unit time, i.e, it refers to the time required to execute a specific task.

4.Reach and Stroke : The distance covered by the end of the wrist to the centre of the body of Robot is called as Reach. The distance covered by the wrist and along with the corresponding link without touching the work part is called as stroke. Stroke is the maximum distance covered by the wrist end of the robot

5. Operating environment : It represents the environment where a robot can work effectively. Some of the different types of working environments specified for robots are

- Complex and contaminated   Ordinary and workable
- Extremely clean and dustless   Hot and Hazardous

(6) Performance parameters : The Robot's precision can be defined as the function of three important factors

(a) Spatial Resolution

(b) Accuracy

(c) Repeatability

(a)Spatial Resolution

It refers to the smallest possible movement which a Robot can move in its work volume. Spatial resolution depends on two factors

- Control Resolution
- Mechanical Inaccuracies

- **Control Resolution**

The capability of a Robot to divide its-work volume into smallest possible increments is called as Control Resolution. These increment are also referred as addressable points

It turn depends on the bit storage capacity of the control memory

Control Resolution for particular axis is

Where S= Stroke or Total Range

$$R = \frac{S}{N}$$

N= Total no. of Increments

$N = 2^n$ n=No.of bits in control memory

$$R = \frac{S}{2^n}$$

- **Mechanical Inaccuracies :**Inaccuracy in the robots links and joints will have effect on spatial resolution . Hydraulic fluids and other imperfections will tends to reduce the resolution of Robot.

It depends on 3factors

- Load carrying capacity
- Speeds
- Maintenance factors

Inaccuracy is high in larger robots than in smaller robots

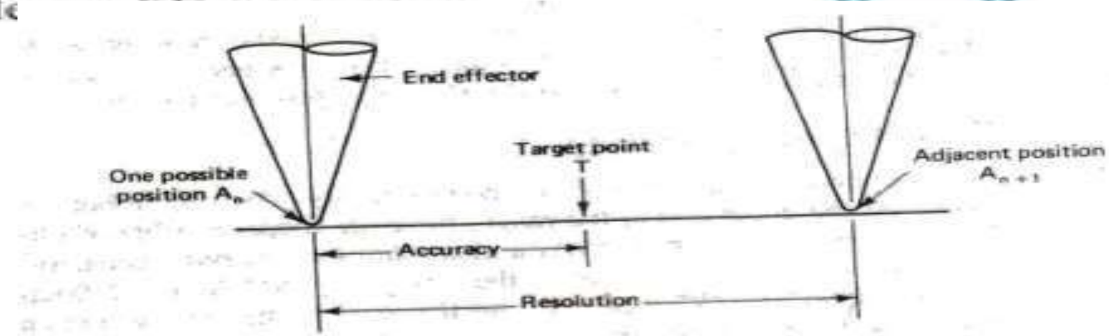
Accuracy

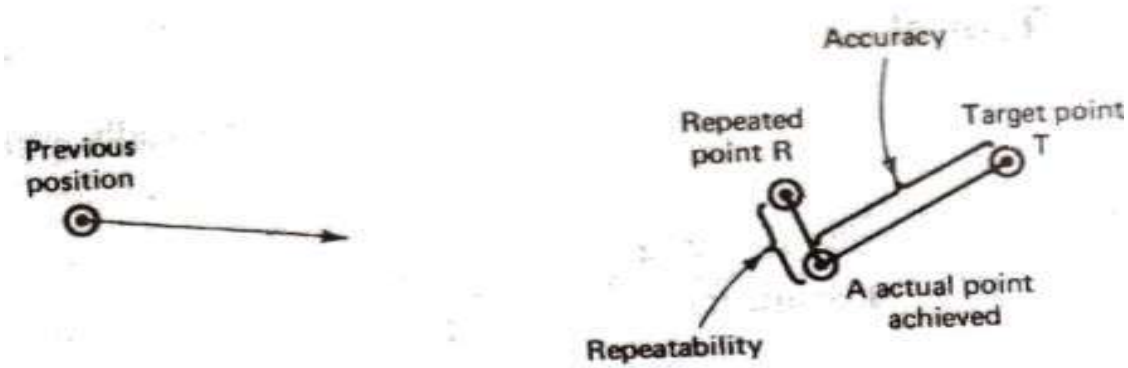
The ability to position wrist end at a desired target with robots work volume is called as Accuracy

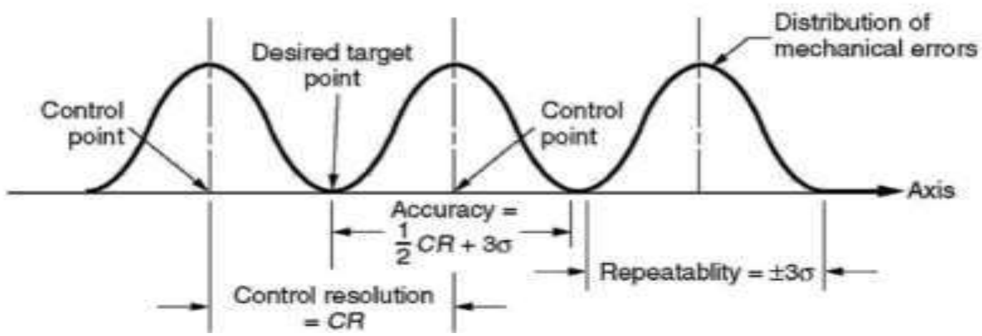
Accuracy will be less when the robot links are fully extended position

Accuracy is less when load carrying capacity is high

Higher the resolution higher the accuracy

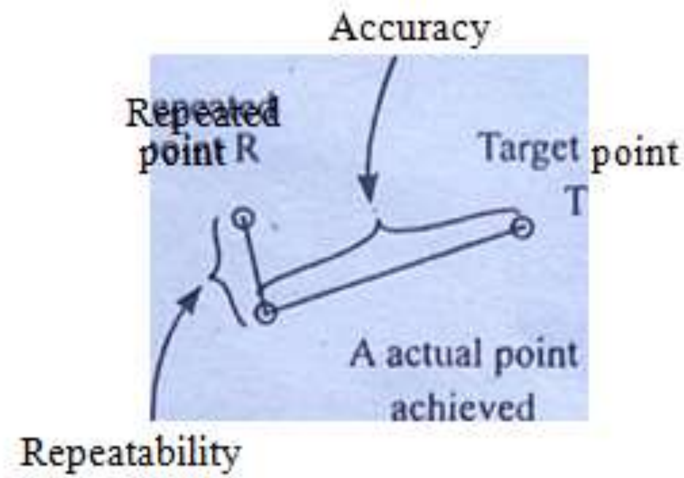

End effector
Target point
T
One possible
position A_n
Adjacent position
A_{n+1}
Accuracy
Resolution


Accuracy
Repeated
point R
Target point
T
Previous
position
A actual point
achieved
Repeatability


Distribution of
mechanical errors
Desired target
point
Control
point
Control
point
Axis
Accuracy =
$\frac{1}{2}CR + 3\sigma$
Repeatablity = $\pm 3\sigma$
Control resolution
= CR

(c)Repeatability : The ability to position the wrist of the robot at the same point again and again is called Repeatability.

The robot mechanism will have some natural variance in it. This means that when the robot is repeatedly instructed to return to the same point, it will not always stop at the same positio



Robot Motions :

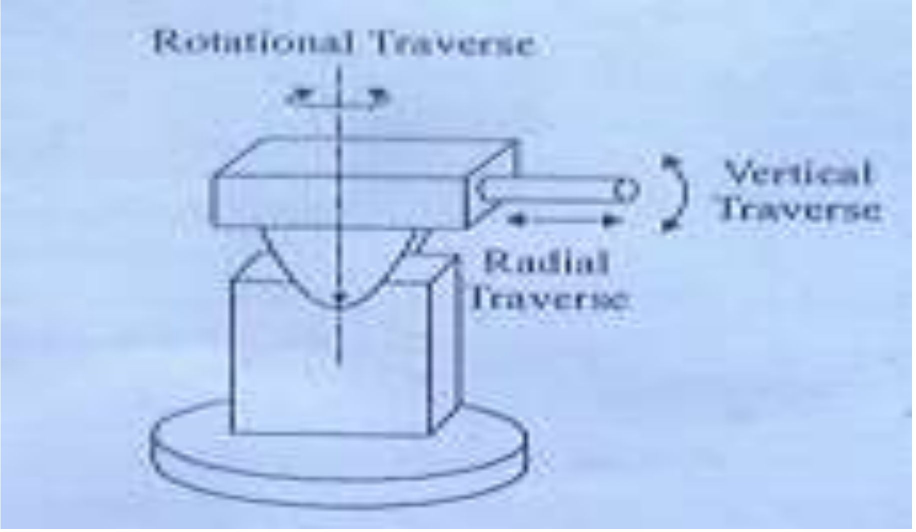
The body and arms of a robot is used to position the wrist. Attached to the I , wrist is the end effector which is used by the robot to perform specific task. The movements in a robot are divided into two categories

l. Arm and body motions .

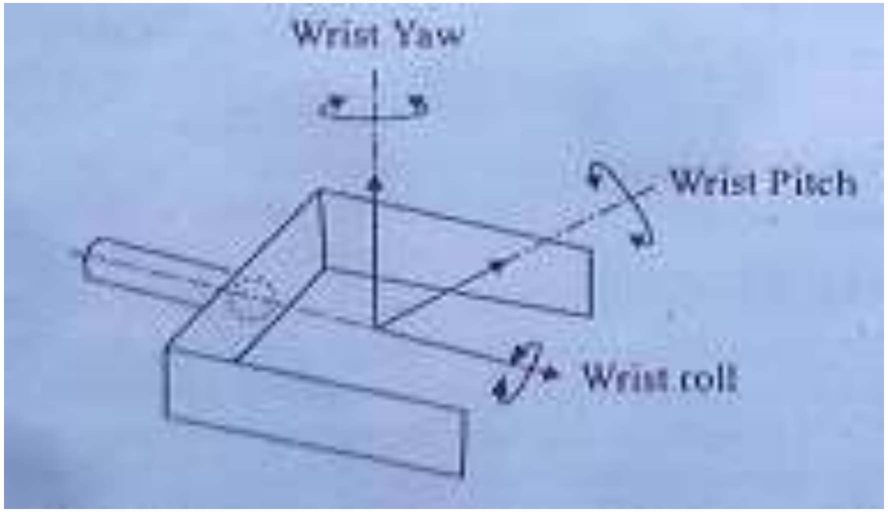
2. Wrist motions.

1.Arm and body motions : The arm and body movements are designed to enable the robot -to move its end effector to a desired position within the limits of the robot's size.'

- Vertical Traverse : The capability to move the wrist up (or) down to provide the desired position in vertical direction is called as Vertical Traverse.
- Radial Traverse ; The extension (or) retraction of the arm to position its wrist is called as Radial Traverse,
- Rotational Traverse ; The rotation of the arm about the vertical axis is called as Rotational Traverse.



2.Wrist motions :Wrist motions are designed to enable the robot to orient the end effector properly With respect to the task to be performed.



(a)Wrist roll : This involves in the rotation of wrist mechanism about arm axis, Wrist roll is also called as “*Wrist Swivel* "

(b)Wrist pitch : This involves in the up and down rotation of the wrist.

Wrist pitch is also called as "*Wrist Bend*",

(c)Wrist yaw : This involves in right or left movement of the wrist

WORK VOLUME

Work volume represents the space within which the robot can manipulate its wrist end. Work volume of a robot is considered up to the wrist end of the robot and not the end effectors because of its size variations

Characteristics of Robot :

- Robot physical configuration.
- Size of the body, arm and wrist components.
- The limits of the robots joint movements.
- The work volume of a polar co-ordinate configuration robot is "Partial sphere".
- The work volume of a cylindrical configuration robot is "Cylindrical"
- The work volume of a Cartesian co-ordinate configuration robot is "Rectangular block"
- Robot Technology
- The work volume of a Jointed - arm - configuration robot is "Irregular"

a)Polar coordinate confg b)Cylindrical coordinate config

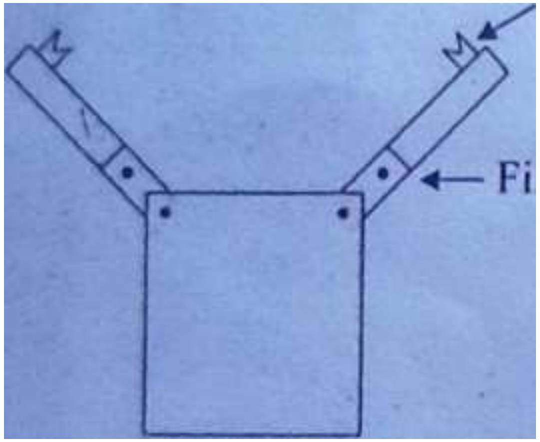
c)Cartesian coordinate confg d) Jointed arm coordinate config

End effectors : The function of a gripper is mainly to translate some form of power into grasping action of the fingers, lie power input is either supplied by pneumatic, Hydraulic (or) Electric means,

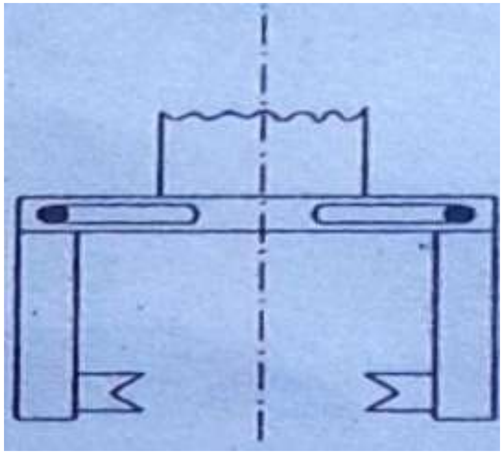
- Grippers include applications like Machine loading and unloading, picking the parts from the conveyor, arranging the parts on the pallet and so on
- Grippers are not only used to handle the work parts but also the raw materials

Mechanical grippers uses mechanical fingers which are used to grasp the object. The fingers are also called as Jaws. The different types of mechanical grippers are shown in figure 8.15.

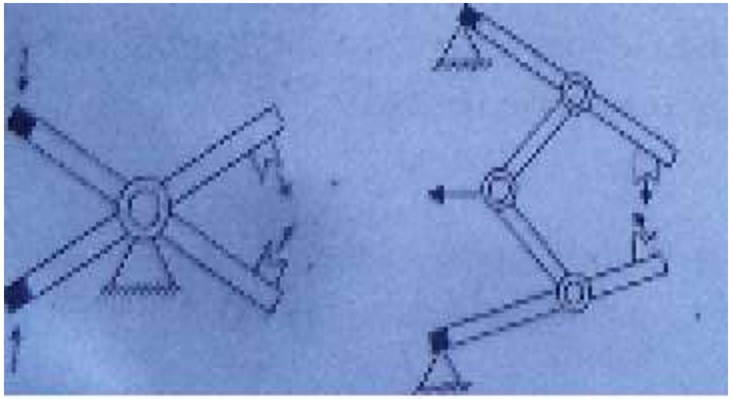
Non-mechanical grippers do not possess jaws to handle the objects, but are used to handle specific shapes of work parts. The different types of Non-mechanical grippers are Vacuum cup grippers, Adhesive grippers, Magnetic grippers, Hooks and so on.



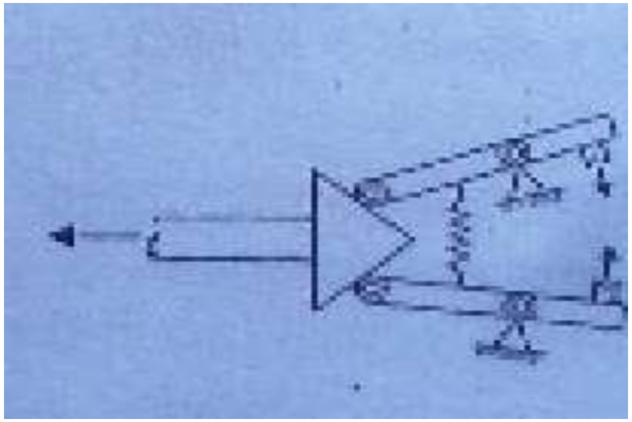
Pivot action Grippers



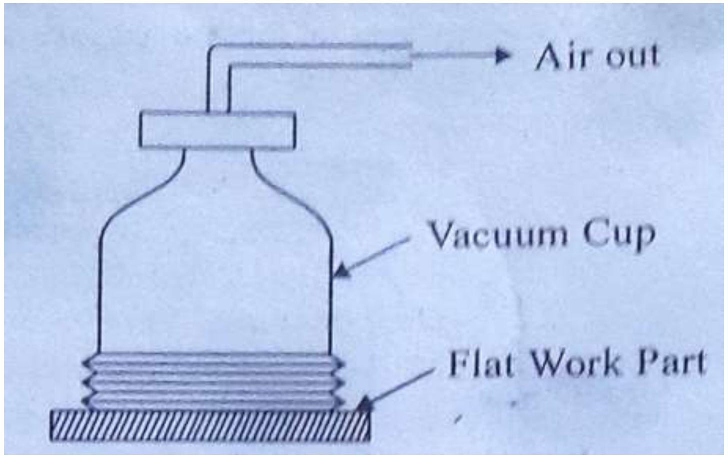
Sliding action grippers



Linkage actuation Grippers



Cam actuated Grippers



Vaccum cup Grippers

Robot Sensors

The interaction of the robot with the environment needs certain mechanisms known as **sensors**. Robot sensors performs several functions like identification of objects, guiding the robot without obstruction, identification of path, object avoidance and so on.

There are basically two types of sensors

l. Internal sensors

2. External sensors

Internal sensors are used to provide the information like joint position, velocity, acceleration etc. Orientation, speed. External sensors provides the information about the external environment surrounding the robot**.**

External sensors are used for Robot navigation, Object identification, Object handling and many other functions

There are two types of external sensors : Contact sensors and Non-contact sensors

The different types of contact sensors are :

(a) Touch sensors

(b) Slip sensors

(c) Force and Torque sensors

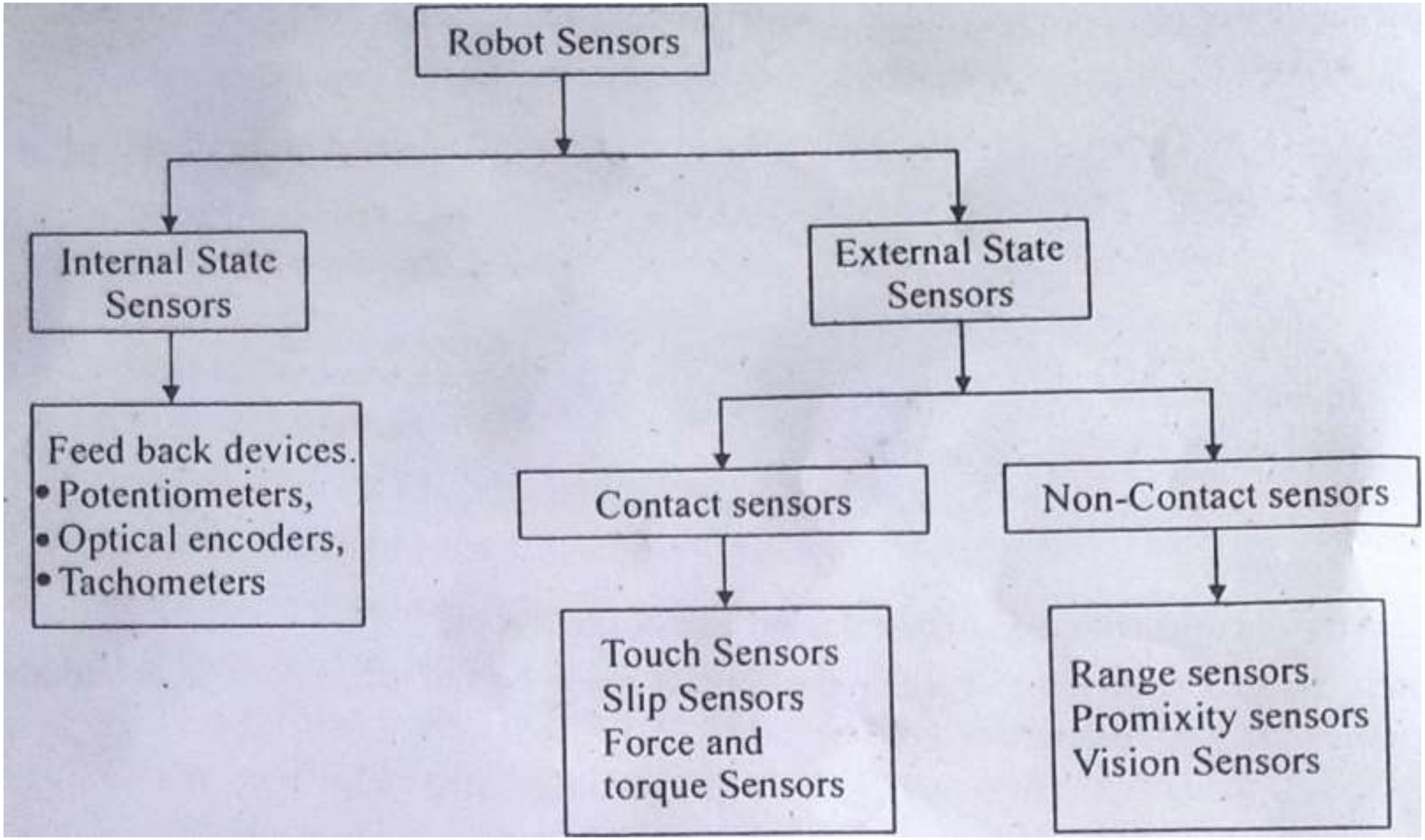
The different types of Non-contact sensors are :

(a) Range sensors

(b)Proximity sensors

(c) Vision sensors

Different types of Robot Sensors



Touch sensors are used in the end effector fingers (jaws). These sensors are used to indicate whether a contact has been established with the object or not. Also these sensors indicates the presence of the object within the fingers of the end effector. These sensors act as a simple micro switches

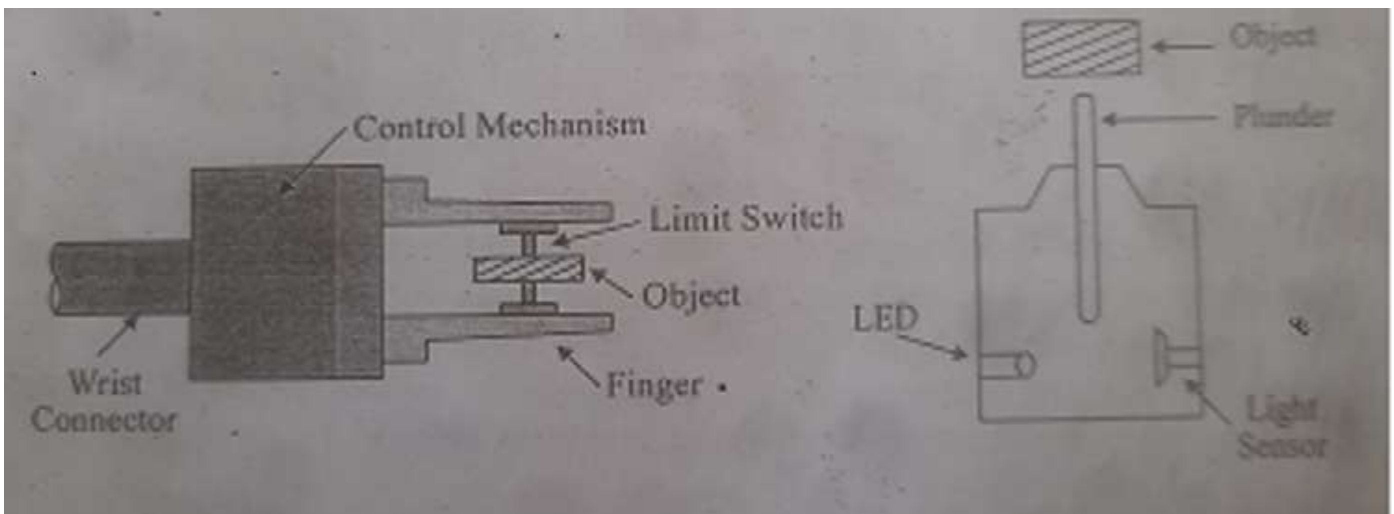


Fig. 8.18 Operation of touch sensors

Array of Touch Sensors: The touch sensors can be systematically arranged in a array and is referred as tactile array of touch sensors. Array of touch sensors is shown in the figure The tactile sensors also provide additional information like size, shape, type of material of the objects.

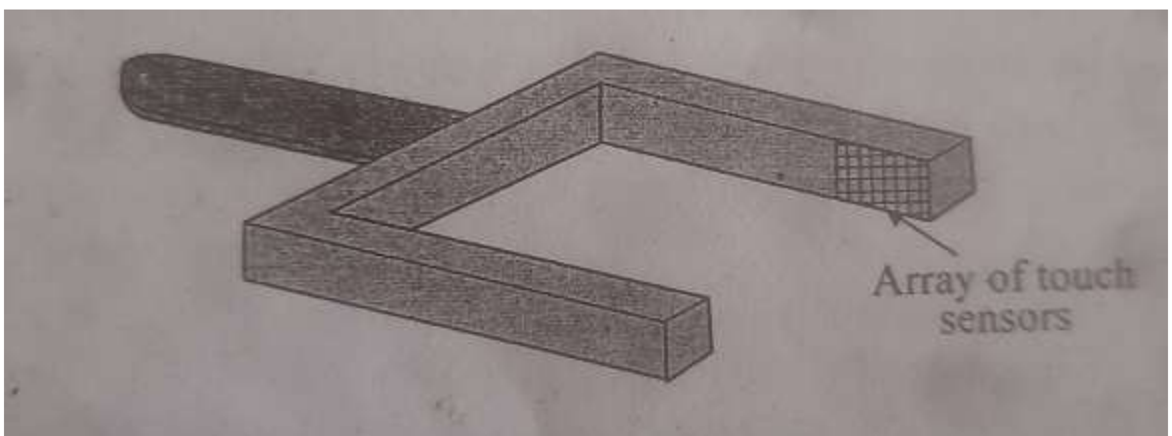


Fig. 8.19 Array of touch sensors.

(b) Slip Sensors : Slip sensors are arranged at the outer surface of the Robot. These sensors are used to specify the contact made by the external objects and also determines the force of contact

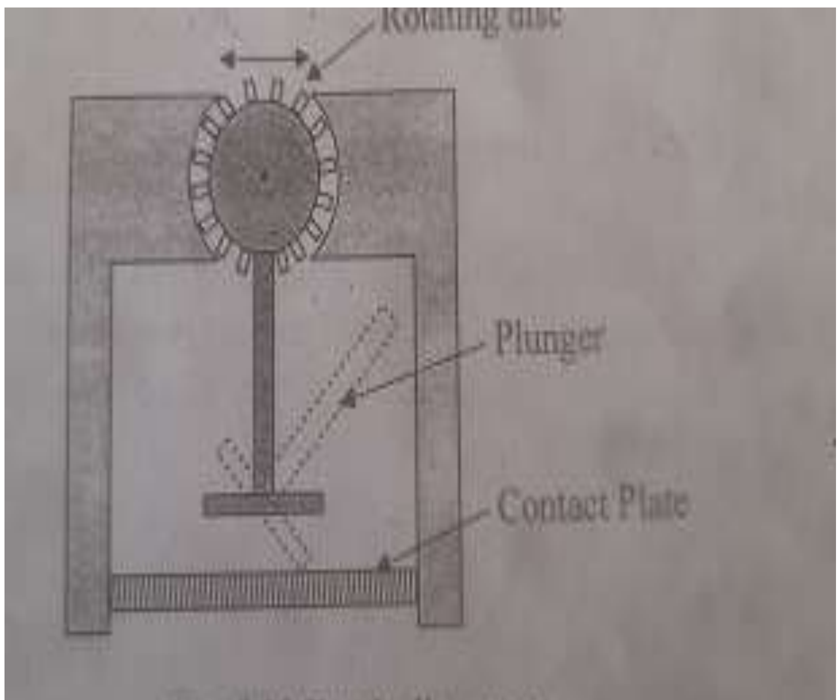
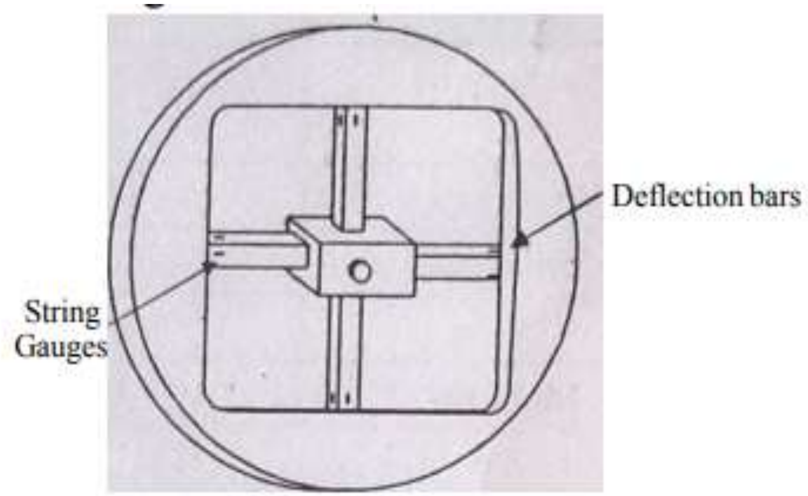


Fig. 8.20 Touch slip sensor

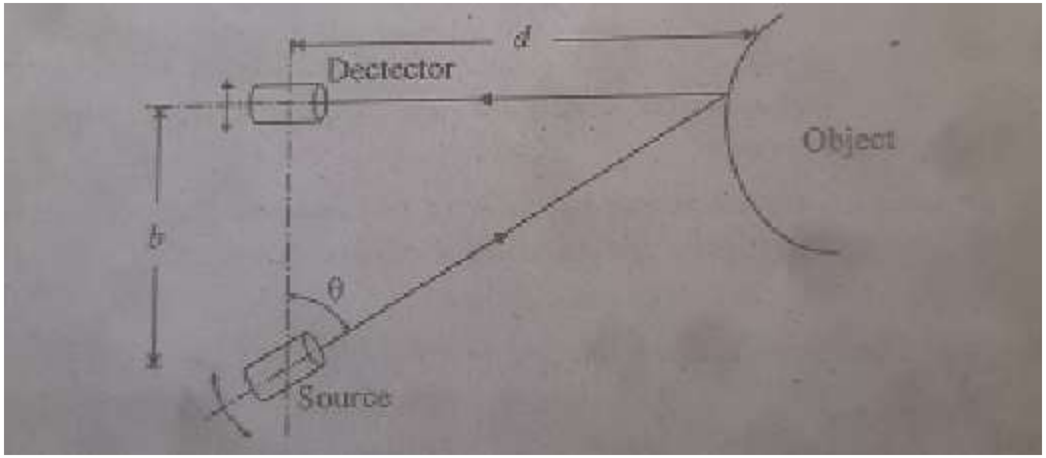
(c) Force and Torque Sensors : Force and torque sensors are primarily used for measuring the reaction forces developed at the interface of mechanical assemblies. In robots, these sensors are used to measure the reaction forces developed at the joints and wrists. These sensors are also called as wrist sensors.

These sensors consist of strain gauges which are connected to potentiometers. Any deflections in the robot are recorded by using these strain gauges and the force can be determined



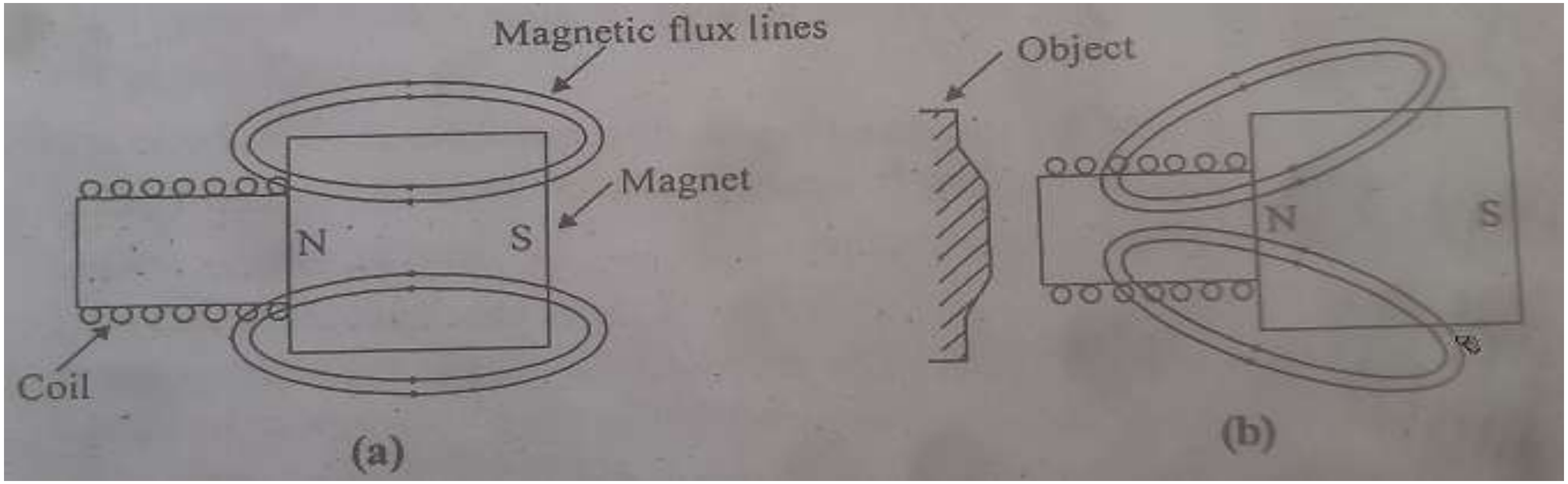
(d)Range Sensors : Range sensors are mainly used to measure the distance between a reference point on the robot and the objects present in its workspace. Range sensors are mainly used for navigation and obstacle avoidance. These sensors uses photoelectric devices to determine the distance.

Simple method for measuring the distance by range sensor is shown in figure



(e) Proximity Sensors : Proximity sensors are used to indicate the presence of an object within a specified distance/ interval without having a physical contact with the object. There are different types of proximity sensors Inductive sensors, Ultra sonic sensors, Hall effect sensors, Photoelectric sensors.

Inductive sensor works on the principle of inductance to determine the presence of the object. The working of an simple inductive sensor is shown in fig Inductive sensor consists of a magnet and an electromagnetic coil placed inside housing. When there is no metallic object near the sensor there will be no movement of flux lines in the magnet as shown in figure



(e) Vision Sensors : These sensors are used to recognize the three dimensional object in the form of picture . These sensors are also called as Robot vision ,Machine vision,(or)Artificial vision

It is one of the important sensor technology with many application s in industrial operations

Machine vision is concerned with sensing of image data

And its interpretation by computers

A typical vision system consists of camera,a digitizing hardware,a digital computer,hardware and softwares

Programming the Robot

Defn. Robot programming can be defined as the path followed by the robot manipulator along with its peripherals to perform a specific task

There are four types of **Programming Methods**

1. Manual Method
2. Walk through Method.(or)Manual lead through
3. Lead through Method (or) Online Method
4. Offline Programming

1.Manual Method

- This method is used only for small robots and for simple application
- This method involves in setting up the machine rather than actual programming
- This Method is accomplished by setting limit switches , Mechanical stops , cams ,relays to control the robot machines
- This method is mainly employed for low technology robots

Walk through Method

- This method is employed for programming the robots with continuous path controls
- In this method the programmer /operator manually moves the arms of the robot through a motion sequence
- Each movement will be recorded in the memory for subsequent play back during Production
- The speed of the movement can be controlled or varied during actual playback
- This method is used to program the robots performing spray painting and welding application

Lead through Method or online programming method

- This method is commonly used to program robots with point to point control
- A hand held control box called as teach pendent is used to drive the robot through its motion sequence
- Each movement is recorded in robots control memory for future play back

Advantages :

- This method is relatively easy and simple
- No special programming skills is required to perform this method

Disadvantages :

- This method cannot be used for large and heavy robots
- Complex movements like curves cannot be achieved
- This method requires lot of memory to store the data

Off line Programming

- This type of programming is not accomplished on the shop floor
- Off-line programming is performed on a computer and then it is entered to the robot memory
- The production time of the robot will not be lost
- This type of programming can be integrated with various CAD/CAM systems

Applications of Industrial Robots

1.Material Transfer

2.Machine loading

3.Welding

4.Spray Painting

5.Processing operations

6.Assembly

7.Inspection

1.Material Transfer :the work rof robot is to move work part from one location to another

1.Material Transfer :

The work of robot is to move work part from one location to another

- Pick and place operations.
- Transfer of material from one conveyor to another conveyor
- Palletizing operation, where robot picks material from conveyor and loads on to (he pallet in a required dimension.
- De-palletizing operation, The application of material transfer is one of easiest and most straight forward of robot application

2. Machine loading:

- This is the process where a robot is required to supply raw material to the processing machine and the unload the finished parts from the machine
- In general, robot picks the work parts from the conveyor and loads on the machine. But in some cases, robots holds the parts in position during processing
- Machine loading application will be very useful in case of Die casting, injection Molding, Hot forging, and in Machining Operation such as Turning, Milling etc.

3. Welding: Welding is one of the important application area in case of Robotic applications. The applications in welding basically is divided into two categories.

(i) Spot Welding

(ii) Arc Welding

- **Spot Welding:**

It is a process where metal parts are fused together at localized points by passing electric current through the two parts. This is done with the help of two electrodes. Robot is used to hold the electrodes in such applications, and through these electrodes electric current is made to pass into the metal parts.

This application is widely used in Automobile Industry,

- **Arc Welding :**

Different types of arc welding can be performed by using Robots like

GMAW-Gas Metal Arc welding

MIG – Metal inert gas welding

TIG - Tungsten inert gas welding

Human workers donot work under hot, uncomfortable and dangerous conditions.

From are welding ,High productivity, Improved safety,More consistent weld can be obtained

4. Spray Coating:

Many industries will be having some form of spray coating application.

Initially, human workers used to do spray coating, which may lead to health hazards

- Spray coating/painting creates toxic atmosphere.
- Noise is produced.
- May result in fire hazard.

So, in this regard, workers are replaced by robots in spray painting.

Advantage:

By using robots in spray painting:

1.Safe in operation.

2.Coating consistency

3.Lower material usage.

4.Less verification requirements.

5.Greater productivity,

5. Processing Operations: these are performed by specialized tools attached to the robots arm, These tools do lot of operations like drilling, Riveting, Grinding, Polishing etc.

6.Assembly :

Robots are widely used for assembly operations in industries ,which may results in increased productivity.

Also robots can do repetative task continuously

7.Inspection :

Workers usually perform sampling techniques rather than 100% inspection

Since quality is important ,each and every product must be inspected

Robots are equipped with mechanical probes , sensors and other measuring devices

Robot Programming Languages

Robots that are not controlled by computers do not require any programming languages

Two different types of robot programming languages

I. The VAL Language.

2.The MCL Language.

The **VAL**

- VAL stands for Victors Assembly Language.
- VAL was developed for PUMA robot.

In this type of programming language various point locations are defined by lead through method and the programming language is used to define the motion sequence through these points.

There are two basic types of statements used in VAL

(a) Monitoring Commands.

(b) Programming Instructions.

Monitoring Commands (a) statements are used to direct the operation of the robot system.

- Monitoring Commands are used to define the point locations, instructing the robot to execute the program and so on.
- Program of instructions are used to define the movements of the robot.
- Program of instruction commands the robot to Move to a Point, to open gripper, Close gripper, Stop the operations and so on.

The MCL

- MCL stands for Machine Control Language.
- MCL is based on APT Language that is used for programming NC machines.
- MCL is enhancement of APT Language which posses additional capabilities to control a robot,
- MCL can be used for complex movements robots and can program the robot for specialized applications.

Programming Statements

Programming statements are used in VAL and MCL are

MOVE P 1 : commands the robot to move from current position to a new position

HERE P 1 : This command is used to store the current position of the robot as point Pl. **OR** LEARN PI

MOVES PI : This directs the robot to move to the new point 'PI ' in straight line. The suffice S' represents as straight line motion

DMOVE (3,50) : The command directs the joint ' 3' to make a incremental movement from its current position by 50 units.

APPROACH PI 10 MM : This command directs to position the robot gripper exactly at 10 mm away from point Pl.

DEPART 20 MM : This command is used to move the robot gripper 20 mm away from its current position.

MOVE PATH 123 : Commands robot to move through a path defined by points PI, and P3.

SPEED 50 : Commands the robot to operate at 50% of the initially commanded velocity.

WAIT 20, ON : Commands to stop program execution temporarily and wait until the input signal through port 20 reaches to robot controller

OPEN/ CLOSE : These two commands directs to open or close the gripper

THANK YOU