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Internal Assessment Test 2 – Dec. 2022

Sub:	Automation and Robotics					Sub Code:	18ME732	Branch:	ME
Date:	2.12.22	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VII/A&B		OBE

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Define automated assembly system? Explain automation assembly configuration systems with suitable sketches	[10]	CO2	L2
2	Define automated identification method and data capture. Explain briefly barcode and RFID?	[10]	CO2	L2
3	Explain Part delivery system at an automated assembly workstations with suitable sketch	[10]	CO2	L2
4	What is an Industrial robot? Explain common robot configurations with suitable diagrams	[10]	CO3	L2
5	Explain briefly end effectors and applications of industrial robots	[10]	CO3	L2
6.	Write short notes on a. Spatial Resolution b. Work volume, c. Accuracy and repeatability d. Types of joints in industrial robots	[10]	CO3	L2

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Scheme of Evaluation

Question number	Particulars	Marks distribution
1.	Definition 4 configurations= Diagram Explanation	2 Marks 4x1= 4Marks 4x1= 4Marks
2.	Definition Barcode RFID	2 Mark 4 Marks 4 Marks
3.	Sketch Components explanation	4 Marks 6 Marks
4.	Definition 4 configurations= Diagram Explanation	2 Marks 4x1= 4Marks 4x1= 4Marks
5.	End effectors Applications of Industrial Robots	5 Marks 5 Marks
6.	a. Robot drive systems b. Work volume c. Accuracy and repeatability d. Types of joints in industrial robots	2 marks 2 marks 2 marks 2 marks

1. An automated assembly system performs a sequence of automated assembly operations to combine multiple components into a single entity. The single entity can be a final product or a subassembly in a larger product.
Automated assembly systems can be classified according to physical configuration. The principal configurations are (a) in-line assembly machine, (b) dial-type assembly machine, (c) carousel assembly system, and (d) single-station assembly machine.

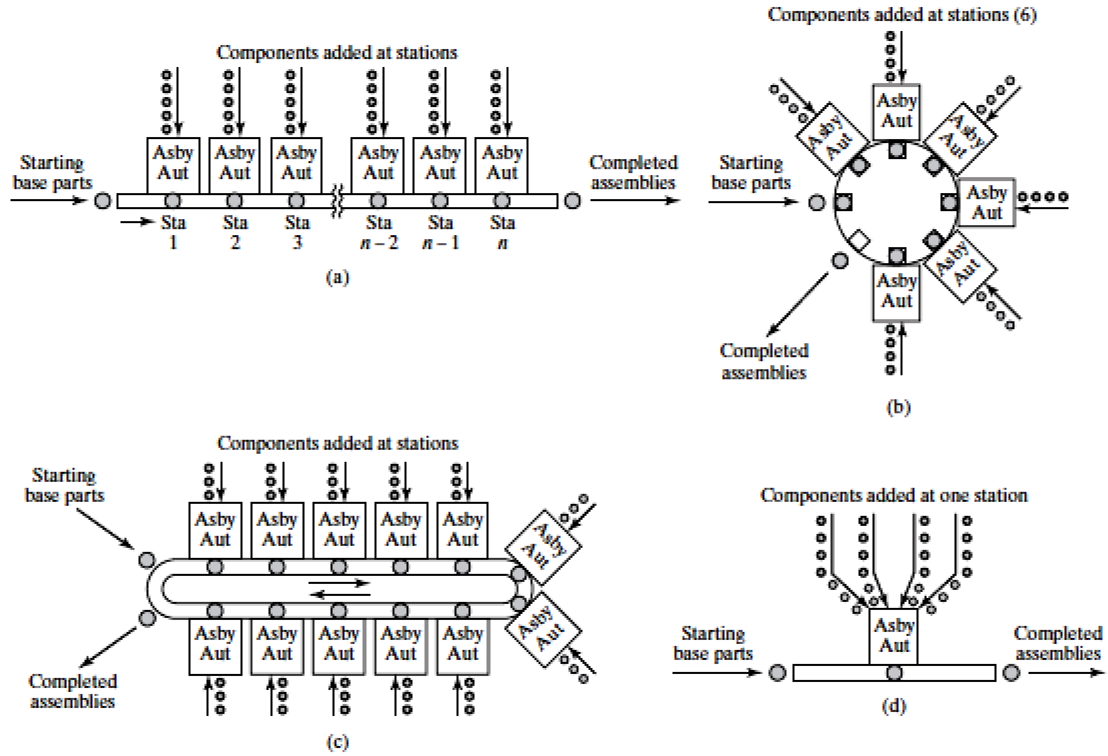


Figure 17.1 Types of automated assembly systems: (a) in-line, (b) dial-type, (c) carousel, and (d) single station.

The in-line assembly machine, Figure 17.1(a), is a series of automatic workstations located along an in-line transfer system. It is the assembly version of the machining transfer line. Synchronous and asynchronous transfer systems are the common means of transporting base parts from station to station with the in-line configuration.

In the typical application of the dial-type machine, Figure 17.1(b), base parts are loaded onto fixtures or nests attached to the circular dial. Components are added and/or joined to the base part at the various workstations located around the periphery of the dial. The dial-indexing machine operates with a synchronous or intermittent motion, in which the cycle consists of the service time plus indexing time. Dial-type assembly machines are sometimes designed to use a continuous rather than intermittent motion. This is common in beverage bottling and canning plants, but not in mechanical and electronics assembly.

The carousel assembly system represents a hybrid between the circular work flow of the dial-type assembly machine and the straight work flow of the in-line system. The carousel configuration can be operated with continuous, synchronous, or asynchronous transfer mechanisms to move the work around the carousel.

In the single-station assembly machine, Figure 17.1(d), assembly operations are performed on a base part at a single location. The typical operating cycle involves the placement of the base part at a stationary position in the workstation, the addition of components to the base, and finally the removal of the completed assembly from the station. An important application of single-station assembly is the component placement machine, widely used in the electronics industry to populate components onto printed circuit boards.

2. ***Automatic identification and data capture*** (AIDC) refers to technologies that provide direct entry of data into a computer or other microprocessor-controlled system without using a keyboard. Bar codes divide into two basic types: (1) linear, in which the encoded data are read using a linear sweep of the scanner, and (2) two-dimensional, in which the encoded data must be read in both directions.

Linear (One-Dimensional) Bar Codes

Linear bar codes are the most widely used automatic identification and data capture technique. There are actually two forms of linear bar code symbologies, illustrated in Figure 12.1: (a) width-modulated, in which the symbol consists of bars and spaces of varying width; and (b) height-modulated, in which the symbol consists of evenly spaced bars of varying height. The only significant application of the height-modulated bar code symbologies is in the U.S. Postal Service for ZIP code identification, so the discussion here focuses on the width-modulated bar codes, which are used widely in retailing and manufacturing.

In linear width-modulated bar code technology, the symbol consists of a sequence of wide and narrow colored bars separated by wide and narrow spaces (the colored bars are usually black and the spaces are white for high contrast). The pattern of bars and spaces is coded to represent numeric or alphanumeric character.

Bar code readers interpret the code by scanning and decoding the sequence of bars. The reader consists of the scanner and decoder. The scanner emits a beam of light that is swept past the bar code (either manually or automatically) and senses light reflections to distinguish between the bars and spaces. The light reflections are sensed by a photo detector, which converts the spaces into an electrical signal and the bars into absence of an electrical signal. The width of the bars and spaces is indicated by the duration of the corresponding signals.

Two-Dimensional Bar Codes

Two-dimensional symbologies divide into two basic types: (1) stacked bar codes and (2) matrix symbologies.

Stacked Bar Codes. The first 2-D bar code to be introduced was a stacked symbology. It was developed in an effort to reduce the area required for a conventional bar code. But its real advantage is that it can contain significantly greater amounts of data. A stacked bar code consists of multiple rows of conventional linear bar codes stacked on top of each other. Several stacking schemes have been devised over the years, nearly all of which allow for multiple rows and variations in the numbers of encoded characters possible.

Matrix Symbologies. A matrix symbology consists of 2-D patterns of data cells that are usually square and are colored dark (usually black) or white. The 2-D matrix symbologies were introduced around 1990. Their advantage over stacked bar codes is their capability to contain more data. They also have the potential for higher data densities—up to 30 times more dense than Code 39. Their disadvantage compared to stacked bar codes is that they are more complicated, which requires more sophisticated printing and reading equipment.

RADIO FREQUENCY IDENTIFICATION

In radio frequency identification, an identification tag or label containing electronically encoded data is attached to the subject item, which can be a part, product, or container (e.g., carton, tote pan, pallet). The identification tag consists of an integrated circuit chip and a small antenna, as pictured in Figure 12.8. These components are usually enclosed in a protective plastic container or are imbedded in an adhesive-backed label that is attached to item. The tag is designed to satisfy the Electronic Product Code (EPC) standard, which is the RFID counterpart to the Universal Product Code (UPC) used in bar codes. The tag communicates the encoded data by RF to a reader or interrogator as the item is brought into the reader's proximity. The reader can be portable or stationary. It decodes and confirms the RF signal before transmitting the associated data to a collection computer.

RF identification tags are available in two general types: (1) passive and (2) active.

Passive tags have no internal power source; they derive their electrical power for transmitting a signal from radio waves generated by the reader when in close proximity. Active tags include their own battery power packs. Passive tags are smaller, less expensive, longer lasting, and have a shorter radio communication range. Active tags generally possess a larger memory capacity and a longer communication range (typically 10 m and more). Applications of active tags tend to be associated with higher value items due to the higher cost per tag.

3. The parts delivery system typically consists of the following hardware.

1. *Hopper*. This is the container into which the components are loaded at the workstation. A separate hopper is used for each component type. The components are usually loaded into the hopper in bulk. This means that the parts are randomly oriented in the hopper.

2. *Parts feeder*. This is a mechanism that removes the components from the hopper one at a time for delivery to the assembly work head. The hopper and parts feeder are often combined into one operating mechanism. A vibratory bowl feeder, pictured in Figure 17.2, is a very common example of the hopper-feeder combination.

3. *Selector* and/or *orientor*. These elements of the delivery system establish the proper orientation of the components for the assembly work head. A ***selector*** is a device that acts as a filter, permitting only parts in the correct orientation to pass through. Incorrectly oriented parts are rejected back into the hopper. An ***orientor*** is a device that allows properly oriented parts to pass through, and reorients parts that are not properly oriented initially. Several selector and orientor schemes are illustrated in Figure 17.3. Selector and orientor devices are often combined and incorporated into one hopper-feeder system.

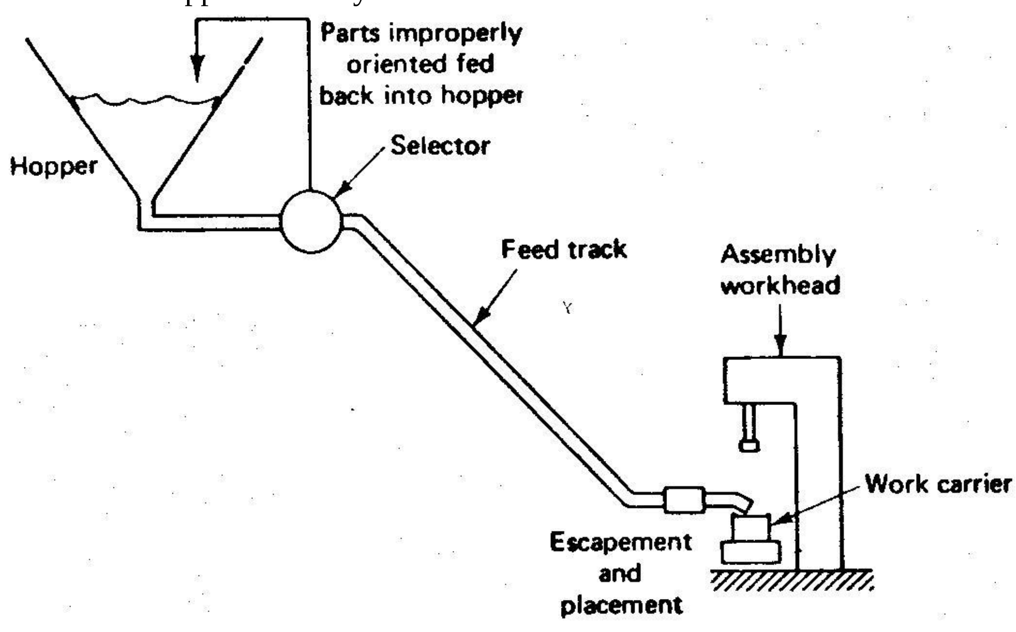


FIGURE 7.6 Elements of the parts delivery system at an assembly workstation.

4. *Feed track.* The preceding elements of the delivery system are usually separated from the assembly work head by a certain distance. A feed track moves the components from the hopper and parts feeder to the location of the assembly work head, maintaining proper orientation of the parts during the transfer. There are two general categories of feed tracks: gravity and powered. Gravity feed tracks are most common. In this type, the hopper and parts feeder are located at an elevation above that of the work head. Gravity is used to deliver the components to the work head. The powered feed track uses vibratory action, air pressure, or other means to force the parts to travel along the feed track toward the assembly work head.
5. *Escapement* and *placement device*. The escapement removes components from the feed track at time intervals that are consistent with the cycle time of the assembly work head. The placement device physically places the component in the correct location at the workstation for the assembly operation. These elements are sometimes combined into a single operating mechanism. In other cases, they are two separate devices.

4. A robot is a reprogrammable multi functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of variety of tasks.

Common robot configurations

1. Polar configuration
2. Cylindrical Configuration
3. Cartesian Configuration
4. Jointed Arm configuration
5. SCARA

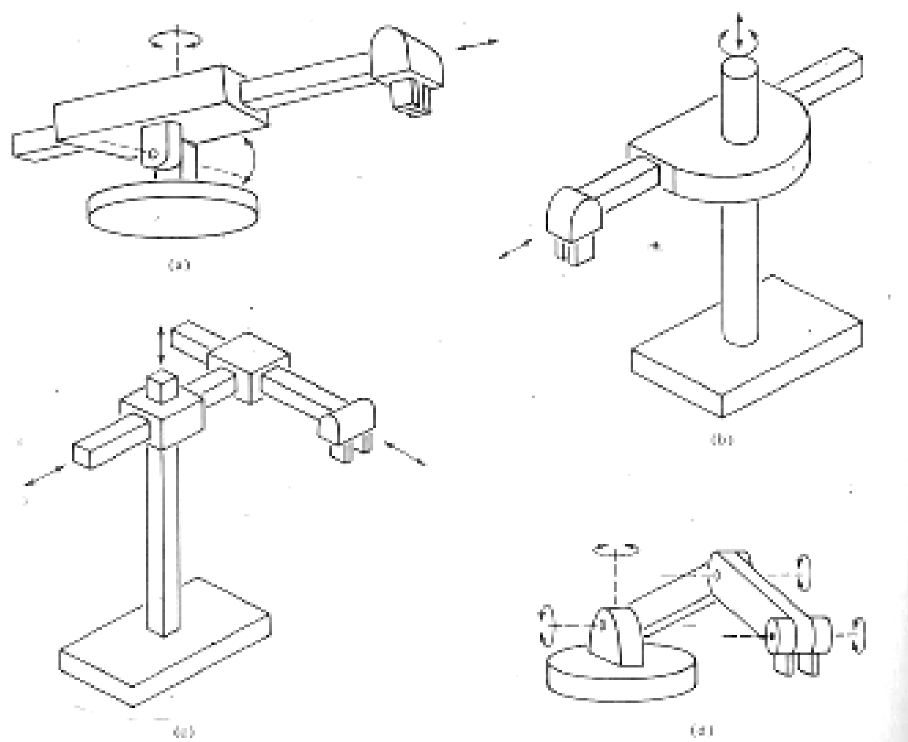


Figure 2-1 The four basic robot anatomies: (a) polar, (b) cylindrical, (c) cartesian, and (d) jointed-arm. (Reprinted from Reference [7].)

1. Polar configuration/Spherical configuration

Notation: [**LTR**]: Linear, Twisting and Rotational joint

This configuration also called as Polar coordinate configuration. It goes by the name "spherical coordinate" also 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 a telescoping arm.

i) Operate within a **spherical** work volume
ii) Has 1 prismatic and 2 revolute axes.
iii) First motion is a base rotation, Second motion correspond to an elbow rotation and Third motion is radial or in-out motion
iv) Elbow rotation and arm reach limit the design of full spherical motion.
v) Rarely used in industries but common in automated cranes.

Notation: [**TLL**]: Twisting, Linear and Linear.

This also has 3 degrees of freedom, 2 prismatic and 1 revolute joints. It moves linearly along X and Y axes and rotaion about at its base i.e. Z- axis. The robot body is a vertical column that swivels about a vertical axis. The arm consists of several orthogonal slides which allow the arm to be moved up or down and in and out with respect to the body. This is illustrated schematically in figure.

Features:

i) Operate within a **cylindrical** work volume
ii) 2 prismatic and 1 revolute joints.
iii) Position is specified by Y value (height) extension of arm X axis and angle of rotation of Z axis (θ)
iv) Recommended for pick and place operation such as machine loading and unloading.
v) Lower repeatability and accuracy
vi) Require more sophisticated control
vii) Rigid structure & high lift-carrying capacity

3. Cartesian / Rectangular configuration

Notation: [**LOO**]: Linear, Orthogonal, Orthogonal

Cartesian configuration is also called as **Rectilinear or Rectangular** configuration as the joints allow only translational or linear relative motion between the adjacent links of the joint. A robot using such a configuration is called as X-Y-Z robot. Other names are xyz robot or Rectilinear robot or **Gantry robot**. Any point in X, Y and Z coordinate system can be reached using this configuration. By appropriate movements of these slides, the robot is capable of moving its arm at any point within its three dimensional rectangular spaced work space.

Features:

i) Operate within a **rectangular** work volume
ii) Three prismatic joints are used.
iii) The position is specified by X, Y and Z locations.
iv) Easy to visualize motion
v) Easy to program the motions
vi) Adapted in gantry crane and CNC milling machines.
vii) Gantry type can handle heavy loads.

viii) Addition axes can be incorporated to the wrist action.
ix) Difficult to protect the sliding axes from contaminants such as dust and moisture as it is open.

4. Revolute / Articulate / Jointed-arm configuration:

Notation: [**TRR**]: Twisting, Rotational and Rotational joint

It 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. The robot arm is mounted to a base which can be rotated to provide the robot with the capacity to work within a quasi-spherical space.

Features:

i) Operate within a **quasi-spherical** work volume.
ii) All 3 are revolute joints.
iii) Can reach above, below and around obstacles.
iv) Joints can be sealed easily.
v) Difficult to calculate angular motion of the axis for a given top or end motion.

5. SCARA (Selective Compliance Assembly Robot Arm)

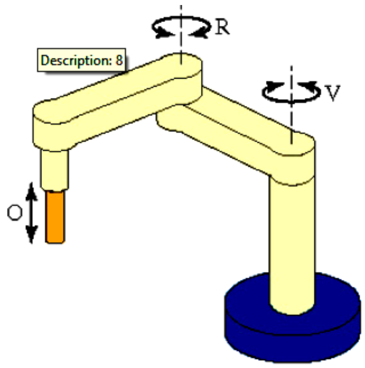
Notation: [**VRL**]: Revolving, Rotational and Linear joint

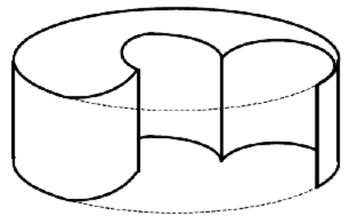
This configuration consists of 1 prismatic and 2 revolute joint. The important features being the relative motion of all the links at the joints are about vertical axes.

SCARA stands for Selective Compliance Assembly Robot Arm. This joint is similar to jointed-arm robot except that vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction for vertical insertion tasks.

Features:

i) Work volume is **cylindrical** in nature
ii) Most common in assembly robot
iii) Arm consists of two horizontal revolute joints at the wrist and elbow and a one prismatic joint
iv) Can reach at any point within horizontal planar defined by two concentric circles
v) Most assembly operations involve building up assembly by placing parts on top of a partially complete assembly
vi) Floor area is small compare to work area
vii) Rectilinear motion requires complex control of the revolute joints





5. ROBOT END EFFECTORS

An end effector is a device that attaches to the wrist of the robot arm and enables the general-purpose robot to perform a specific task. It is sometimes referred to as the robot‘s “hand.”

Types of end effectors
The End effectors can be divided into two major categories:

1. Grippers
2. Tools

Grippers are end effectors used to grasp and manipulate objects during the work cycle. The objects are usually work parts that are moved from one location to another in the cell. Machine loading and unloading applications fall into this category. Owing to the variety of part shapes, sizes, and weights, most grippers must be custom designed. Types of grippers used in industrial robot applications include the following:

- *Mechanical grippers*, consisting of two or more fingers that can be actuated by the robot controller to open and close on the work part (Figure 8.10 shows a two-finger gripper)
- *Vacuum grippers*, in which suction cups are used to hold flat objects
- *Magnetized devices*, for holding ferrous parts
- *Adhesive devices*, which use an adhesive substance to hold a flexible material such as a fabric
- *Simple mechanical devices,* such as hooks and scoops.

Tools are end effectors designed to perform work on the part rather than to merely grasp it. By definition, the tool-type end effector is attached to the robot’s wrist. One of the most common applications of industrial robots is spot welding, in which the welding electrodes constitute the end effector of the robot. Other examples of robot applications in which tools are used as end effectors include spray painting and are welding.

Applications of Robots

Robots are used in a wide field of applications in industry. Most of the current applications are in manufacturing. The applications can usually be classified into one of the following categories: (1) material handling, (2) processing operations, and (3) assembly and inspection.

Material Handling Applications

In material handling applications, the robot moves materials or parts from one place to another. To accomplish the transfer, the robot is equipped with a gripper that must be designed to handle the specific part or parts to be moved. Included within this application category are (1) material transfer and (2) machine loading and/or unloading. In many material handling applications, the parts must be presented to the robot in a known position and orientation. This requires some form of material handling device to deliver the parts **Material Transfer.** A more complex example of material transfer is ***palletizing***, in which the robot retrieves parts, cartons, or other objects from one location and deposits them onto a pallet or other container at multiple positions on the pallet. Other applications similar to palletizing include ***depalletizing***, which consists of removing parts from an ordered arrangement in a pallet and placing them at another location (e.g., onto a moving conveyor); ***stacking*** operations, which involve placing flat parts on top of each other, such that the vertical location of the drop-off position is continuously changing with each cycle; and ***insertion*** operations, in which the robot inserts parts into the compartments of a divided carton.

Machine Loading and/or Unloading. In machine loading and/or unloading applications, the robot transfers parts into and/or from a production machine. The three possible cases are (1) machine loading, in which the robot loads parts into the production machine, but the parts are unloaded from the machine by some other means; (2) machine unloading, in which the raw materials are fed into the machine without using the robot, and for a robot palletizing operation into the work cell in this position and orientation. the robot unloads the finished parts; and (3) machine loading and unloading, which involves both loading of the raw work part and unloading of the finished part by the robot. Industrial robot applications of machine loading and/or unloading include the following processes:

Processing Operations

In processing applications, the robot performs some operation on a work part, such as grinding or spray painting.

Spot Welding. Spot welding is a metal joining process in which two sheet metal parts are fused together at localized points of contact. Two electrodes squeeze the metal parts together and then a large electrical current is applied across the contact point to cause fusion to occur. The use of industrial robots in this application has dramatically improved the consistency of the welds.

Arc Welding. Arc welding is used to provide continuous welds rather than individual spot welds at specific contact points. The resulting arc-welded joint is substantially stronger than in spot welding. **Spray Coating. Spray coating** directs a spray gun at the object to be coated. Fluid (e.g., paint) flows through the nozzle of the spray gun to be dispersed and applied over the surface of the object. Spray painting is the most common application in the category, but spray coating refers to a broader range of applications that includes painting.

Assembly and Inspection

In some respects, assembly and inspection are hybrids of the previous two categories: material handling and processing. Assembly and inspection can involve either the handling of materials or the manipulation of a tool.

Assembly

Assembly involves the combining of two or more parts to form a new entity, called a subassembly or assembly. The new entity is made secure by fastening the parts together using mechanical fastening techniques (e.g., screws, bolts and nuts, rivets) or joining processes (e.g., welding, brazing, soldering, or adhesive bonding). Industrial robots used for the types of assembly operations described here are typically small, with light load capacities. The most common configurations are jointed arm, SCARA, and Cartesian coordinate.

Inspection.

There is often a need in automated production to inspect the work that is done. Inspections accomplish the following functions: (1) making sure that a given process has been completed, (2) ensuring that parts have been assembled as specified, and (3) identifying flaws in raw materials and finished parts.

6. **Spatial Resolution**

The spatial resolution of a robot is the smallest increment of movement into which the robot can divide its work volume. Spatial resolution depends on two factors: the system's control resolution and the robot's mechanical inaccuracies. It is easiest to conceptualize these factors in terms of a robot with 1 degree of freedom.

The control resolution is determined by the robot's position control system and its feedback measurement system. It is the controller's ability to divide the total range of movement for the particular joint into individual increments that can be addressed in the controller. The increments are sometimes referred to as "addressable points." The ability to divide the joint range into increments depends on the bit storage capacity in the control memory. The number of separate, identifiable increments (addressable points) for a particular axis is given by

Number of increments = 2"

where n = the number of bits in the control memory.

For example, a robot with 8 bits of storage can divide the range into 256 discrete positions. The control resolution would be defined as the total motion range divided by the number of increments. We assume that the system designer will make the entire increments equal.

b. Robot Work Volume

It is the term that refers to the space within which the robot can manipulate its wrist end. The convention of using the wrist end to define the robot's work volume is adopted to avoid the complication of different sizes of end effectors that might be attached to the robot's wrist. The end effector is an addition to the basic robot and should not be counted as part of the robot‘s working space. A long end effector mounted on the wrist would add Significantly to the extension of the robot compared to a smaller end effector.

Also, the end effector attached to the wrist might not be capable of reaching certain points within the robot's normal work volume because of the particular combination of joint limits of the arm.

The work volume is determined by the following physical characteristics of the robot.

The robot's_physical configuration

The sizes of the body, arm, and wrist components

The limits of the robot's joint movements.

c. Accuracy

Accuracy refers to a robot's ability to position its wrist end at a desired target point within the work volume. The accuracy of a robot can be defined in terms of spatial resolution because the ability to achieve a given target-point depends on how closely the robot can define the control increments for each of its joint motions. In the worst case, the desired point would lie in the middle between two adjacent control increments.

Repeatability

Repeatability is concerned with the robot's ability to position its wrist or an end effector attached to its wrist at a point in space that had previously been taught to the robot. Repeatability and accuracy has to two different aspects of the robot's precision.

Accuracy relates to the robot's capacity to be programmed to achieve a given target point. The actual programmed point will probably be different from the target point due to limitations of control resolution. Repeatability refers to the robot's ability to return to the programmed point when commanded to do so.

d. The five joint types are

1. *Linear joint* (type L joint). The relative movement between the input link and the output link is a translational telescoping motion, with the axes of the two links being parallel.

2. *Orthogonal joint* (type O joint). This is also a translational sliding motion, but the input and output links are perpendicular to each other.
3. *Rotational joint* (type R joint). This type provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input and output links.
4. *Twisting joint* (type T joint). This joint also involves rotary motion, but the axis of rotation is parallel to the axes of the two links.
5. *Revolving joint* (type V joint, V from the “v” in revolving). In this joint type, the axis of the input link is parallel to the axis of rotation of the joint, and the axis of the output link is perpendicular to the axis of rotation.