AVIT
AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY

VINAYAKA MISSION'S RESEARCH FOUNDATION

Accredited by NAAC   Approved by AICTE

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ROBOTICS LABORATORY

REGULATIONS 2017

NAME :____________________________________

REG NO :____________________________________

BRANCH :____________________________________

<u>**LIST OF EXPERIMENTS**</u>

Sl No	Date	Name of the Experiment	Page No	Marks	Signature
1		Study of Different Types of Robots Based on Configuration and Application			
2		Study of Different Type of Links And Joints Used in Robots			
3		Study of Components of Robots With Drive System and End Effectors			
4		Motion Planning of Robotic Arm in Circular Path			
5		Motion Planning of Robotic Arm in Straight Line Path			
6		Pick and Place Operation By Robotic Arm			
7		Study of Vision System and Use it For Assembly and Inspection			

HOD/EEE
Dr. L. Chitra

Experiment No : Date :

STUDY OF DIFFERENT TYPES OF ROBOTS BASED ON CONFIGURATION AND APPLICATION

AIM :

To Study of different types of robots based on configuration and application.

DESCRIPTION :

Common Robot Configurations:

- ✓ Cartesian – Three linear movement
- ✓ Cylindrical - two linear and one revolute joint
- ✓ Spherical – one linear and two revolute joint
- ✓ Articulated - all three revolute (human arm)

Cartesian Configuration:

The arm movement of a robot using the Cartesian configuration can be described by three intersecting perpendicular straight lines, referred to as the X, Y, and Z axes .Because movement can start and stop simultaneously along all three axes, motion of the tool tip is smoother. This allows the robot to move directly to its designated point, instead of following trajectories parallel to each axis. The rectangular work envelope of a typical Cartesian configuration is illustrated in figure. One advantage of robots with a Cartesian configuration is that their totally linear movement allows for simpler controls. They also have a high degree of mechanical rigidity, accuracy, and repeatability. They can carry heavy loads, and this weight lifting capacity does not vary at different locations within the work envelope. As to disadvantages, Cartesian robots are generally limited in their movement to a small, rectangular work space.

Typical applications for Cartesian robots include the following:

- ✓ Assembly
- ✓ Machining operations
- ✓ Adhesive application
- ✓ Surface finishing
- ✓ Inspection
- ✓ Water jet cutting
- ✓ Robotic X-ray and neutron radiography
- ✓ Automated CNC lathe loading and operation
- ✓ Remotely operated decontamination
- ✓ Advanced munitions handling.

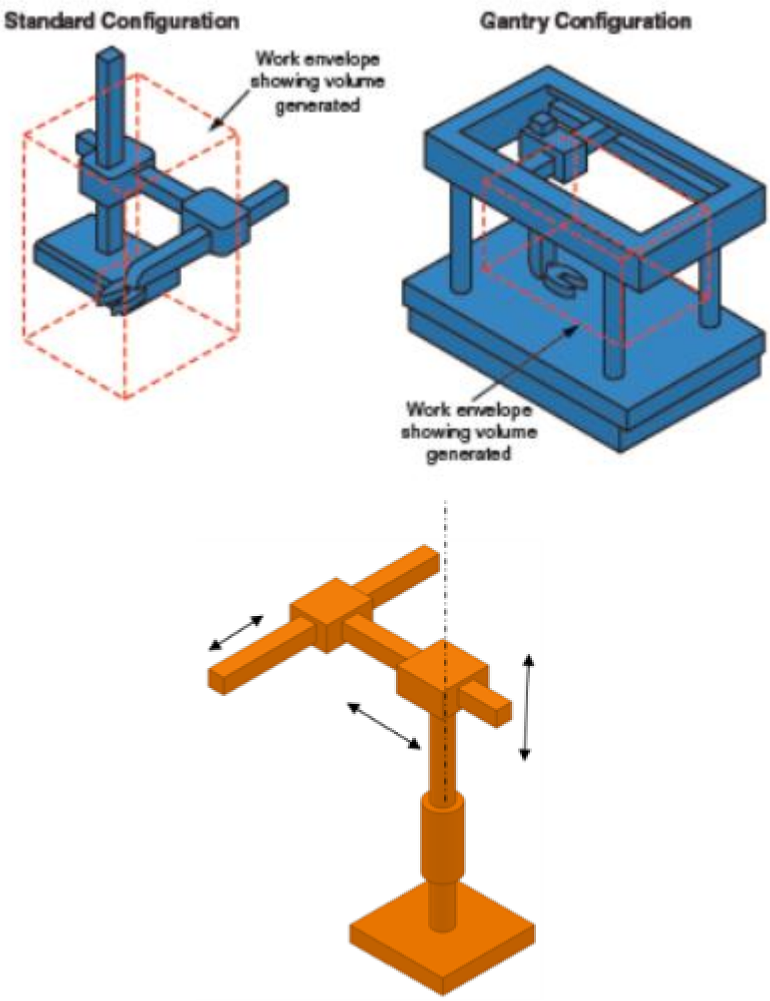


Fig : Cartesian Configuration

Cylindrical Configuration:

A cylindrical configuration consists of two orthogonal slides, placed at a 90° angle, mounted on a rotary axis. Reach is accomplished as the arm of the robot moves in and out. For vertical movement, the carriage moves up and down on a stationary post, or the post can move up and down in the base of the robot. Movement along the three axes traces points on a cylinder.

A cylindrical configuration generally results in a larger work envelope than a Cartesian configuration. These robots are ideally suited for pick-and place operations. However, cylindrical configurations have some disadvantages. Their overall mechanical rigidity is reduced because robots with a rotary axis must overcome the inertia of the object when rotating. Their repeatability and accuracy is also reduced in the direction of rotary movement. The cylindrical configuration requires a more sophisticated control system than the Cartesian configuration.

Typical applications for cylindrical configurations include the following:

- ✓ Machine loading and unloading
- ✓ Investment casting
- ✓ Conveyor pallet transfers
- ✓ Foundry and forging applications
- ✓ General material handling
- ✓ Meat packing
- ✓ Coating applications
- ✓ Assembly
- ✓ Injection molding

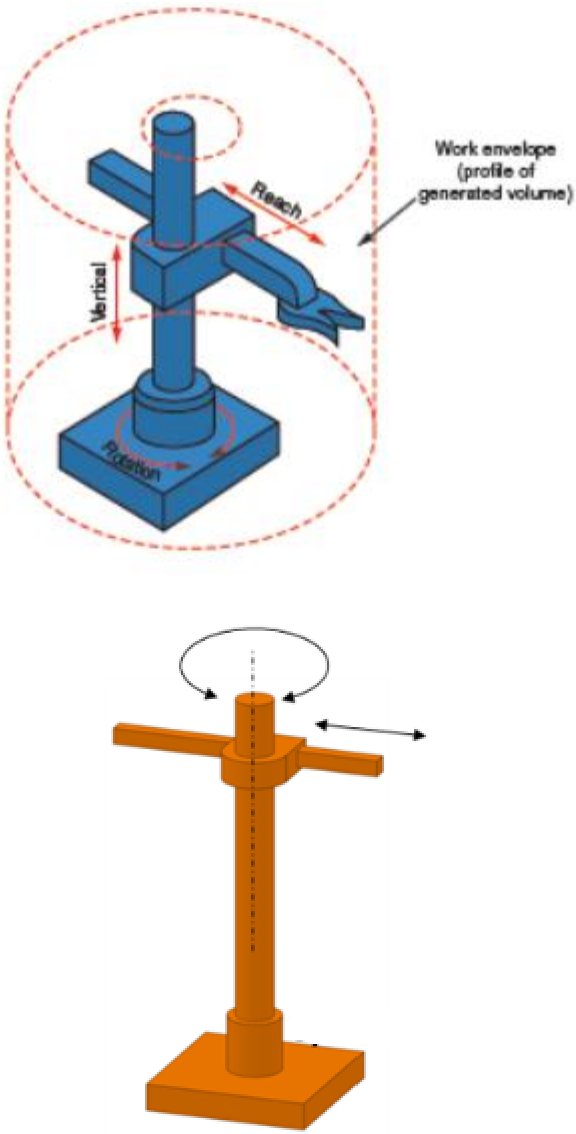
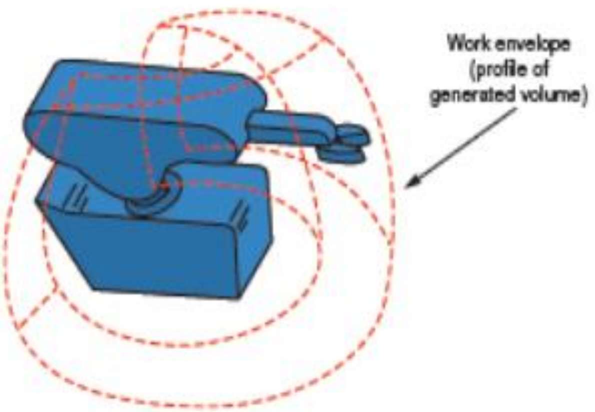


Fig : Cylindrical Configuration

Spherical Configuration (Polar)

The spherical configuration, sometimes referred to as the polar configuration, resembles the action of the turret on a military tank. A pivot point gives the robot its vertical movement, and a telescoping boom extends and retracts to provide reach. Rotary movement occurs around an axis perpendicular to the base. Fig illustrates the work envelope profile of a typical spherical configuration robot. The spherical configuration generally provides a larger work envelope than the Cartesian or cylindrical configurations.

The design is simple and provides good weight lifting capabilities. This configuration is suited to applications where a small amount of vertical movement is adequate, such as loading and unloading a punch press. Its disadvantages include reduced mechanical rigidity and the need for a more sophisticated control system than either the Cartesian or cylindrical configurations. The same problems occur with inertia and accuracy in this configuration as they do in the cylindrical configuration. Vertical movement is limited, as well.



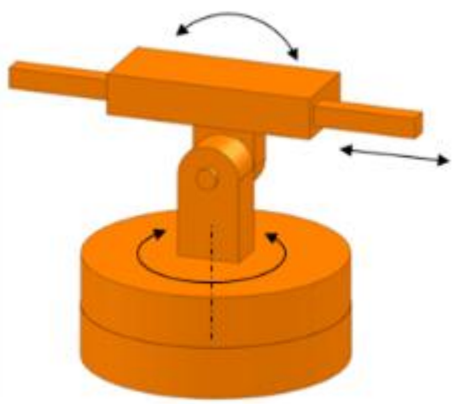


Fig : Spherical Configuration

Typical applications of spherical configurations include the following:

- ✓ Machine tool loading
- ✓ Heat treating
- ✓ Glass handling

- ✓ Parts cleaning
- ✓ Dip coating
- ✓ Press loading
- ✓ Material transfer
- ✓ Stacking and un stacking

Revolute Configuration (Articulated)

The revolute configuration, or jointed-arm, is the most common. These robots are often referred to as anthropomorphic because their movements closely resemble those of the human body. Rigid segments resemble the human forearm and upper arm. Various joints mimic the action of the wrist, elbow, and shoulder. A joint called the sweep represents the waist. A revolute coordinate robot performs in an irregularly shaped work envelope. There are two basic revolute configurations: vertically articulated and horizontally articulated. The vertically articulated configuration has five revolute (rotary) joints.

A vertically articulated robot is depicted. The jointed-arm, vertically articulated robot is useful for painting applications because of the long reach this configuration allows. The horizontally articulated configuration generally has one vertical (linear) and two revolute joints. Also called the SCARA (selective compliance assembly robot arm) configuration. The primary objective was a configuration that would be fairly yielding in horizontal motions and rather rigid in vertical motions. The basic SCARA configuration, is an adaptation of the cylindrical configuration. The SCARA robot is designed for clean-room applications, such as wafer and disk handling in the electronics industry. SCARA robots are ideally suited for operations in which the vertical motion requirements are small compared to the horizontal motion requirements. Such an application would be assembly work where parts are picked up from a parts holder and moved along a nearly horizontal path to the unit being assembled.

The revolute configuration has several advantages. It is, by far, the most versatile configuration and provides a larger work envelope than the Cartesian, cylindrical, or spherical configurations. It also offers a more flexible reach than the other configurations, making it ideally suited to welding and spray painting operations. However, there are also disadvantages to the revolute configuration. It requires a very sophisticated controller, and programming is more complex than for the other three configurations.

Different locations in the work envelope can affect accuracy, load-carrying capacity, dynamics, and the robot’s ability to repeat a movement accurately. This configuration also becomes less stable as the arm approaches its maximum reach.

Typical applications of revolute configurations include the following:

- ✓ Automatic assembly
- ✓ Parts and material handling

- ✓ In-process inspection
- ✓ Palletizing
- ✓ Machine loading and unloading
- ✓ Machine vision
- ✓ Material cutting
- ✓ Material removal
- ✓ Thermal coating
- ✓ Paint and adhesive application
- ✓ Welding
- ✓ Die casting

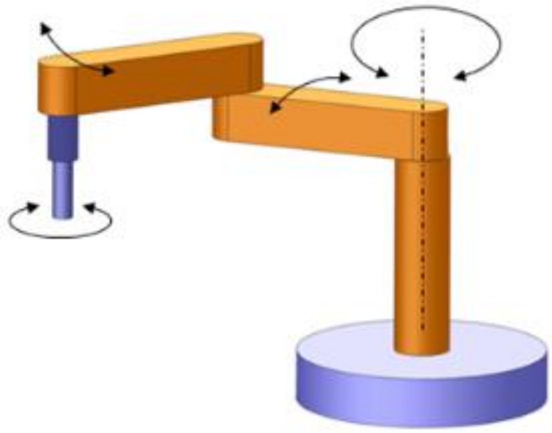


Fig : SCARA

RESULT :

Thus the different types of robots based on configuration and application are studied.

Experiment No : Date :

STUDY OF DIFFERENT TYPE OF LINKS AND JOINTS USED IN ROBOTS

AIM :

To Study of different types of links and joints used in Robots.

DESCRIPTION :

Joints and Links:

The manipulator of an industrial robot consists of a series of joints and links. Robot anatomy deals with the study of different joints and links and other aspects of the manipulator's physical construction. A robotic joint provides relative motion between two links of the robot. Each joint, or axis, provides a certain degree-of-freedom (DOF) of motion. In most of the cases, only one degree-of-freedom is associated with each joint. Therefore the robot's complexity can be classified according to the total number of degrees-of-freedom they possess.

Each joint is connected to two links, an input link and an output link. Joint provides controlled relative movement between the input link and output link. A robotic link is the rigid component of the robot manipulator. Most of the robots are mounted upon a stationary base, such as the floor. From this base, a joint-link numbering scheme may be recognized as shown in Figure. The robotic base and its connection to the first joint are termed as link-0. The first joint in the sequence is joint-1. Link-0 is the input link for joint-1, while the output link from joint-1 is link-1—which leads to joint-2. Thus link 1 is, simultaneously, the output link for joint-1 and the input link for joint-2. This joint-link-numbering scheme is further followed for all joints and links in the robotic systems.

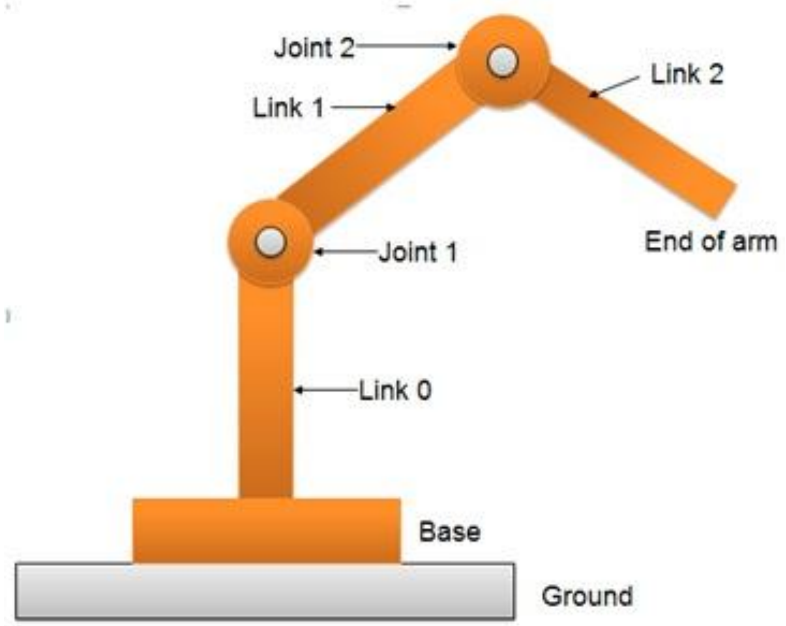


Fig : Joint-link scheme for robot manipulator

Classification of Robot Joints:

Nearly all industrial robots have mechanical joints that can be classified into one of the five types:

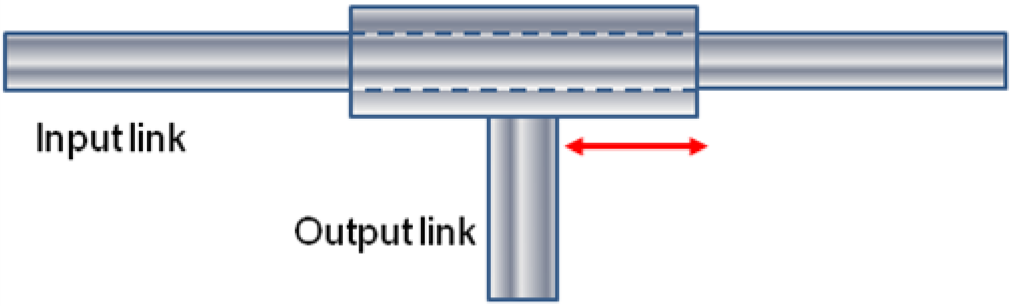
- ✓ Two types that provide translational motion.
- ✓ Three types that provide rotary motion

a) Linear joint (type L joint):

The relative movement between the input link and the output link is a translational sliding motion, with the axes of the two links being parallel.

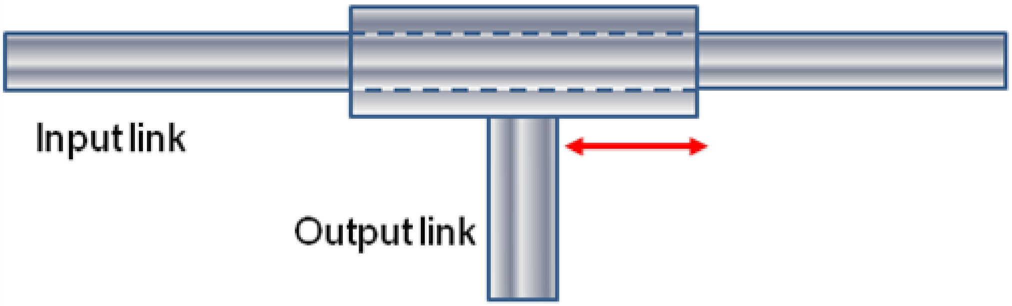
b) Orthogonal joint (type U joint):

This is also a translational sliding motion, but the input and output links are perpendicular to each other during the move.



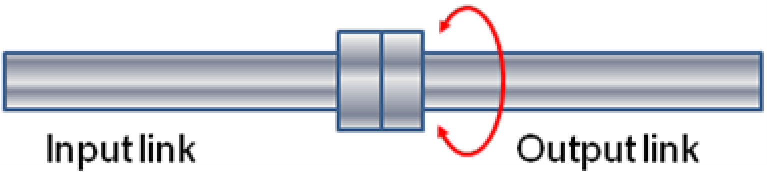
c) Rotational joint (type R joint) :

This type provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input and output links.



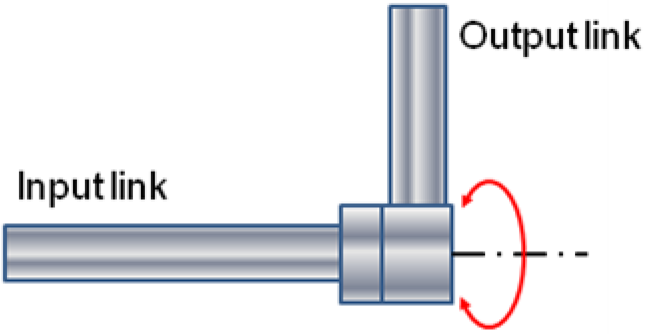
d) Twisting joint (type T joint) :

This joint also involves rotary motion, but the axis or rotation is parallel to the axes of the two links.



e) Revolving joint (type V-joint, V from the "v" in revolving):

In this type, axis of input link is parallel to the axis of rotation of the joint. However the axis of the output link is perpendicular to the axis of rotation.



RESULT :

Thus the different types of links and joints used in Robots were studied.

Experiment No : Date :

STUDY OF COMPONENTS OF ROBOTS WITH

DRIVE SYSTEM AND END EFFECTORS

AIM :

To Study of components of robots with drive system and end effectors.

DESCRIPTION :

Robot system components:

1. Base
2. Manipulator arm
3. End-effector
4. Actuators and transmissions
5. Controller
6. Sensors

BASE:

The base may be fixed or mobile.

MANIPULATOR ARM

- ✓ The most obvious mechanical configuration of the robot is the manipulator arm.
- ✓ There are several designs of the arm to facilitate movement within the work envelope with maximum possible load and speed with high precision and repeatability.
- ✓ The simplest robot may be a two or three axes arm. The axis is meant to understand independent movement or degree of freedom.
- ✓ A robotic manipulator arm consists of several separate links making a chain.
- ✓ In a fixed base, six degree of freedom robot, the first three links of the manipulator constitute the body and they help to place the end-effector at a desired location.

  The remaining three links make up the writ of the manipulator & used to define the orientation of the manipulator end points.
- ✓ The bodies of the open chain are usually links which are joined together by some lower pair connectors.

i) Revolute pair (P) … (1 DOF)

It permits relative rotation about a unique pair axis and has a single degree of freedom

ii) Prismatic pair (P)… (1 DOF)

It allows relative sliding parallel with a unique pair axis and has one degree of freedom

iii) Cylindric Pair (C)…. (2 DOF)

It permits independent relative rotation about and relative sliding parallel to a pair axis and it has two degree of freedom

iv) Spherical pair (S),,,, (3 DOF)

It is a ball and socket joint that permits relative rotation about three non-coplanar interacting axes and has three degree of freedom.

END – EFFECTOR:

- ✓ Robot end effector is the gripper or end of arm tooling mounted on the wrist of the robot manipulator arm.
- ✓ A robot performs a variety of tasks for which various tooling and special grippers are required to be designed
- ✓ A robot manipulator is fixed and adaptable, but its end effector is task specific.

The wide range of gripping methods include:

- ✓ Mechanical clamping
- ✓ Magnetic gripping
- ✓ Vacuum gripping

ACTUATOR AND TRANSMISSION

ACTUATOR:

The robot arm can be put to a desired motion with its payload if actuator modules are fitted in to provide power drives to the systems.

i) Pneumatic Drives:

- ✓ These systems use compressed air to move the robot arm
- ✓ The pneumatic systems may employ a linear actuator, i.e double acting cylinders or it may employ rotary actuator like vane motors.. However, linear actuator are more popular.
- ✓ Non servo robots can be built up with pneumatically powered actuators

ii) Hydraulic Drives

- ✓ In a hydraulic system. The electric pumps fluid form a reserve tank to the hydraulic actuators which are in general, double acting piston cylinder assemblies.
- ✓ The hydraulic drives have high payload capacities and are relatively easy to maintain

iii) Electrical Drives:

- ✓ These drives are clean and quiet with a high degree of accuracy and reliability.
- ✓ They also offer a wide range of payload capacity, accompanied by an equality wide range of costs..
- ✓ Example: Brushless DC motors, Reversible A.C servo motors and stepper motors

TRANSMISSIONS:

Transmissions are elements between the actuators and the joints of the mechanical linkage.

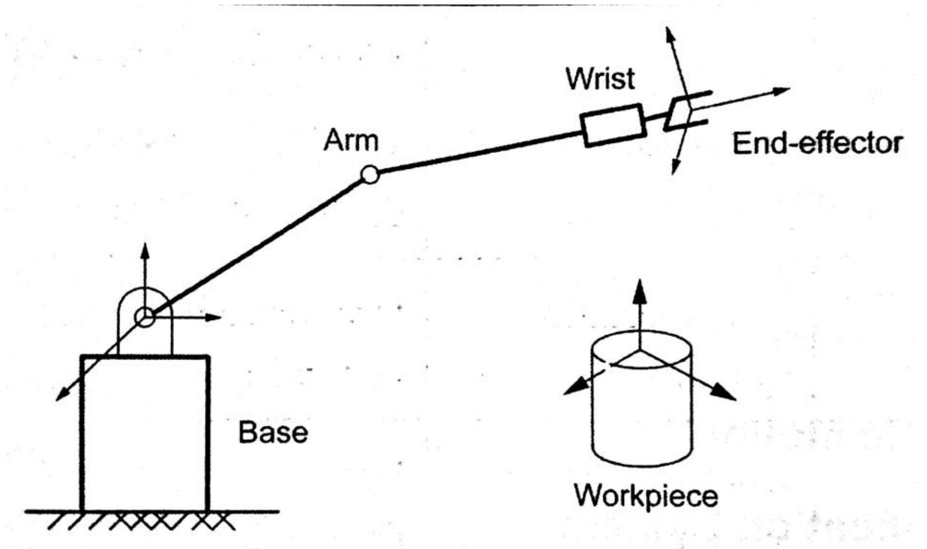
They are generally used for the following reasons:

- ✓ Often the actuator output is not directly suitable for driving the robot linkage.
- ✓ The output of the actuator may be kinematically different from the joint motion
- ✓ The actuators are usually big and heavy and often it is not practical to locate the actuator at the joint.

CONTROLLERS:

The controllers provides the intelligence that is necessary to control the manipulator system.

- It looks at the sensory information and computes the control commands that must be sent to the actuator to carry out the specified tasks. It includes:
  - ✓ Memory to store the control program and the state of the robot system obtained from the sensors.
  - ✓ A computational unit that computes the control commands.
  - ✓ The appropriate hardware to interface with the external world.
- The user interface allows the use of human operator to monitor or control the operation of the robot.
  - ✓ It must have a display that shows the status of the system
  - ✓ It must also have an input device that allows the human to enter command to the robot



RESULT :

Thus the different types of links and joints used in Robots were studied.

Experiment No : Date :

MOTION PLANNING OF ROBOTIC ARM IN CIRCULAR PATH

Aim :

The objective of this exercise is to write a program to make the Youbarm to follow a circular path.

Description:

- ✓ Open a new scene from the file menu of VREP simulation software.
- ✓ From the model browser open folder named mobile.
- ✓ Drag down the model browser and pick up the KUKA YOUBOT and place it in the simulation environment.
- ✓ Now select the child script of YOUBOT and delete all the program codes
- ✓ Define at least 10 points by creating a dummy and placing it in the specific location to form a circular (reference frame).
- ✓ Now develop your own algorithm to make the Youbot arm to follow the predefined path.

Pseudo code :

if (simGetScriptExecutionCount()==0) then

Get all necessary objects handle

simHandleChildScript(sim_handle_all_except_explicit)

Define the set of points to be followed

Set target position points to gripper

Call inverse Kinematics algorithm

Give incremental position to the gripper

Stop the gripper at the goal

End

Result:

Thus successful simulation of movement of Youbot arm to follow a specific path has been successfully done.

Experiment No :   Date :

MOTION PLANNING OF ROBOTIC ARM IN STRAIGHT LINE PATH

Aim :

The objective of this exercise is to write a program to move the Youbot arm from its start position to goal position such that it follows a straight-line trajectory using the Lua script and create successful simulation in VREP simulation software.

Description:

- ✓ Open a new scene from the file menu of VREP simulation software.
- ✓ From the model browser open folder named mobile.
- ✓ Drag down the model browser and pick up the KUKA YOUBOT and place it in the simulation environment.
- ✓ Now select the child script of YOUBOT and delete all the program codes
- ✓ Define the goal point by creating a dummy and placing it in the specific location (reference frame).
- ✓ Now develop your own algorithm to move the Youbot arm from start to goal position
- ✓ Calculate the shortest distance from the start to goal point by the distance formula.
- ✓ Now define your own logic to give velocity to each wheel and make the robot to stop near the goal.

Pseudo code :

```
if (simGetScriptExecutionCount()==0) then
Get all necessary objects handle
simHandleChildScript(sim_handle_all_except_explicit)
Define start and goal point for the arm
Calculate shortest distance
Call inverse Kinematics algorithm
Give incremental position to the gripper
Stop the gripper at the goal
End
```

Result:

Thus successful simulation of movement of Youbot arm from a specific start point to a goal point has completed.

Experiment No : Date :

PICK AND PLACE OPERATION BY ROBOTIC ARM

Aim :

The objective of this exercise is to write a program to up pick an object from the floor and place the object in same position using the Lua script in VREP simulation software.

Description:

- ✓ Open a new scene from the file menu of VREP simulation software.
- ✓ From the model browser open folder named mobile.
- ✓ Drag down the model browser and pick up the KUKA YOUBOT and place it in the simulation environment.
- ✓ Now right click on the mouse and select add primitive shape.
- ✓ In primitive shape select cuboid and a window will open.
- ✓ Now select pure shape in the window and create a cuboid of dimension 0.04
- ✓ Now add a dummy similar to the steps for creating cuboid and place it in the center of the cuboid
- ✓ Now make the dummy a child of the cuboid by right clicking the dummy and cuboid and selecting the option "last selected object a parent".
- ✓ Select the cuboid and now select object/item shift from menubar, give position values such that cuboid is placed in the platform of the YOUBOT.
- ✓ Now select the child script of YOUBOT and delete all the program codes
- ✓ Type the following command "**if (simGetScriptExecutionCount()==0) then**" in child script of Youbot
- ✓ Now develop your own algorithm to pick up the object from the location and place it on the same location using the Lua script functions.

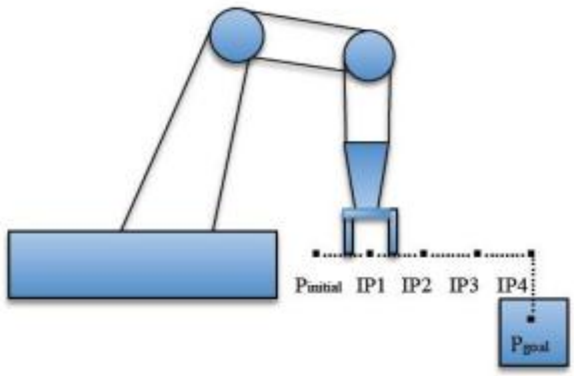


Fig : Model movement of the arm

Pseudo code :

if (simGetScriptExecutionCount()==0) then

Get all necessary objects handle

simHandleChildScript(sim_handle_all_except_explicit)

Define start and goal point

Calculate intermediate points for the arm to follow

Set the arm to follow the points.

Result:

Thus successful simulation of picking up an object and placing back in its own position using Lua script programming tool has been done.

Experiment No : Date :

STUDY OF VISION SYSTEM AND USE IT FOR ASSEMBLY AND INSPECTION

AIM :

To Study of vision system and use it for assembly and inspection.

DESCRIPTION :

Introduction:

Machine Vision:

Machine vision (MV system) is the application of computer vision to industry and manufacturing. Whereas computer visions is mainly focused on machine- based image Processing , machine vision most often requires also digital input/output devices and Computer networks to control other manufacturing equipment such as robotic arms.

Machine Vision a subfield of engineering that encompasses computer science, optics mechanical engineering, and industrial automation.

Machine vision systems are programmed to perform narrowly defined tasks such as counting objects on a conveyor, reading serial numbers and searching for surface defects.

Define Vision:

A vision system can be defined as a system for automatic acquisition and analysis of images to obtain desired data for interpreting or controlling an activity.

THE COMPONENTS OF A VISION SYSTEM

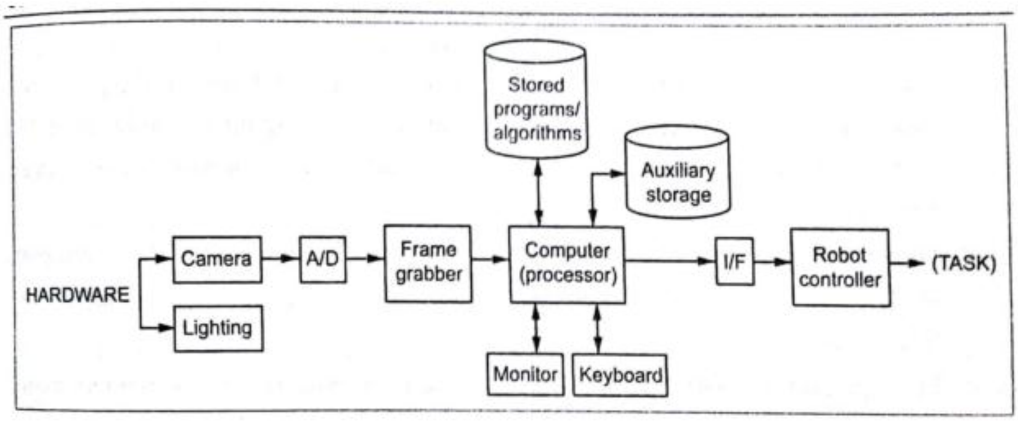


Fig : Components Of A Machine Vision System

ASSEMBLY OPERATIONS :

Robots find applications in assembly areas involving :

i. Screwing of studs and screws in threaded holes.
ii. Screwing and unscrewing of nuts
iii. Insertions of shafts in holes
iv. Insertions of electronic components in electronic assemblies.
v. Assemblies of small electric motors, plugs, switches, etc.

So far maximum potential for robot application is observed only in back type assembly work.

- ✓ Human beings are capable assembling a group of diverse parts to produce either a finished product or a subassembly because of their ability to utilize good eye-hand coordination in conjunction with the important sense of touch. However, these jobs may be extremely tedious because of their repetitious nature. Therefore, there is a need to automate the assembly process.
- ✓ However, not every final product may qualify for automated assembly. The requirements for the improved, more efficient "robotic assembly" are :
    - Faster robots.
    - Limited capability cheap robots.
    - Versatile and inexpensive grippers.
    - Identification of assembly families.
    - Improved assembly efficiency.

- Low cost feeders.

✓ The design for robotic assembly should evolve from the design of the product. The important points to be considered for design of robotic assembly are:

   i. The components for the assembled product should be selected for ease of assembly
   ii. Parts should be designed for feeding and orienting for automated assembly for which product simplification and if necessary, redesigning the products are necessitated.

✓ *The compliance of the gripper is the most important property in the assembly.*

Robots for assembly work :

The following three main types of robots are suitable for assembly operations :

(i) Cartesian robots:

✓ Cartesian (or gantry) robots with the gripping device having 2-3 DOF are suitable for simple assembly operations as they have high accuracy and repeatability

(ii) Revolute robots :

✓ These robots are also used for assembly tasks.

✓ PUMA (Programmable Universal Machine for Assembly) type robots that operate on high level languages, VAL and VAL II or V^+ have six DOFs. They have two coordinate systems:

- World coordinate system
- Tool coordinate system

(iii) SCARA robots :

✓ These robots are provided with direct drive motors that allow high speed with accelerations and backlash-free, fast and accurate motions.

✓ The accuracy is around ± 0.076 mm and repeatability is ±0.025

INSPECTION OF PARTS :

Robots have been employed to inspect finished parts or subassemblies in order to increase product quality. The *"automobile industry"* is an example of a group of companies that is striving to upgrade its product by automating the inspection process,

Inspection of *"electronic devices"* has also been performed by robots. For example a printed circuit (PC) board often must be checked for missing or improperly drilled holes before the components are placed on the board. Two techniques can be used to accomplish this :

- ✓ In the first, the robot picks up the board and puts it onto a special-purpose jig. Probes extend through properly drilled holes and make contact with electrodes on the other side of the board. If all contacts are made, the part is good and the robot can place it in the appropriate bin. If there is even one missing contact, the robot's program branches and causes the PC board to be placed in the reject bin.
- ✓ The second technique utilises a "vision system" that consists of one or more video cameras. The robot places the PC board on a light table. The pattern of light passing through the drilled holes is sensed by the vision system and compared to a stored pattern for a good board. The vision system then commands the robot to place the part in the correct bin.

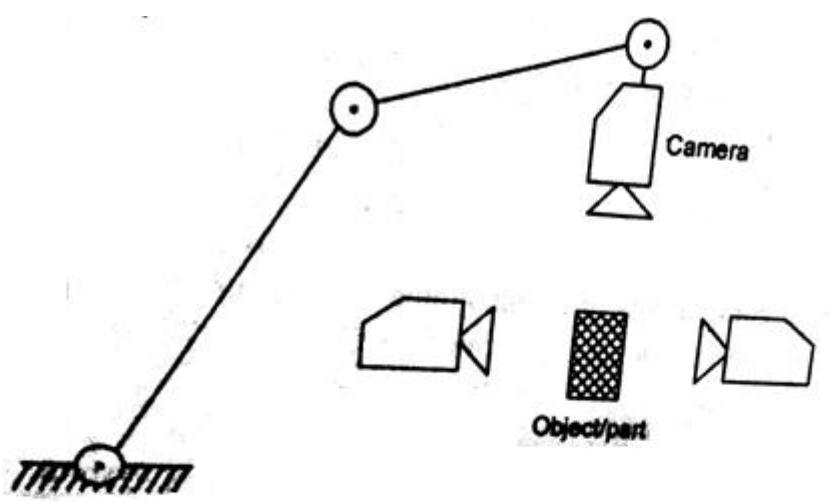


Fig : Inspection Task

RESULT :

Thus the vision system and uses for assembly and inspection were studied.