IPE-419 Computer Integrated Manufacturing

Dr. Nafis Ahmad
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Industrial Robotics

Industrial Robotics

- Introduction
- Robot Anatomy and Related Atributes
  - Joints and Links
  - Common Robot Configurations
  - Joint Drive Systems
- Robot Control Systems
- End Effectors
  - Grippers
  - Tools
- Industrial Robot Application
  - Material Handling Applications
  - Processing Operations
  - Assembly and Inspection
- Robot Programming

Industrial Robotics-Introduction

List the processes done by robots in car industries

Industrial Robotics

- What is industrial robot?

  General purpose programmable machine
  -has arms to perform various industrial task
  -respond to sensor inputs
  -communicate with other machines
  -make decision

- Importance of Industrial robots: (Fukushima Atomic Power Plant, robots making robots at Fanuc, robots in car production etc.)

  -use in hazardous and uncomfortable work environments
  -consistency and repeatability
  -easy to reprogram
  -easy to connect with other computer systems

Industrial Robotics-Anatomy and related attributes

- Robot manipulators consists of joints and links

Joints -provide relative motion between two parts of body
-provide the robot DOF
-almost in all cases one joint gives one dof.
-various joint types: linear and rotary

Links -rigid components of the robot manipulator

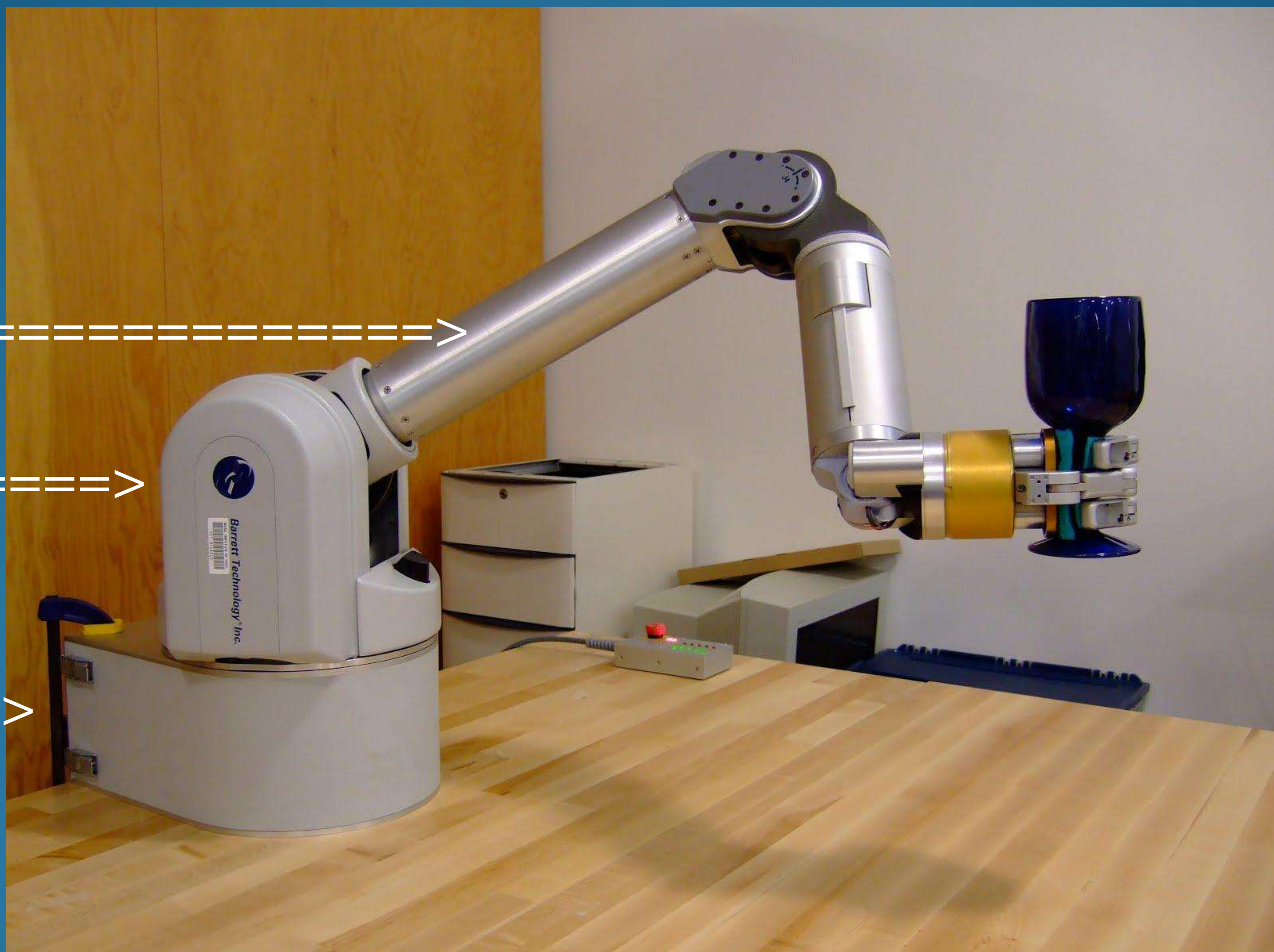
- Types of joint
  - Linear joint (type L joint)
  - Orthogonal joint (type O joint)
  - Rotational joint (type R joint)
  - Twisting joint (type T joint)
  - Revolving joint (type V joint)

Industrial Robotics-Anatomy and related attributes

Link ================>

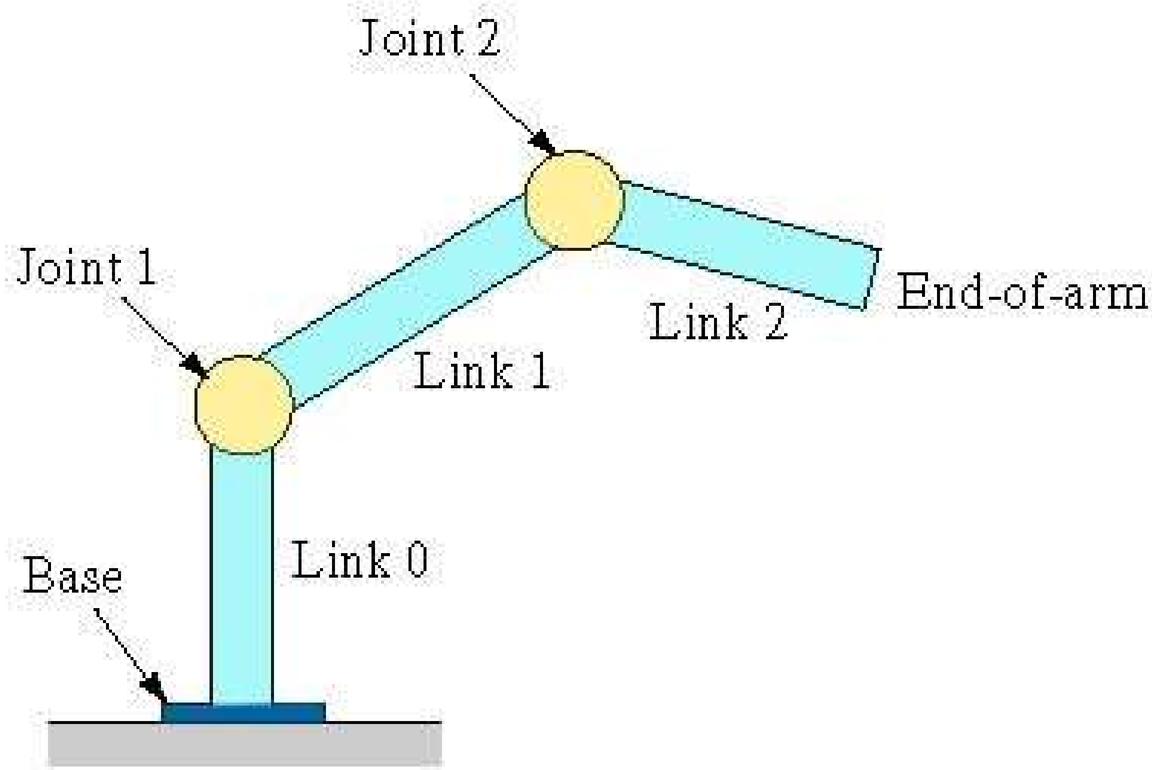
Joint=====>

Base==>



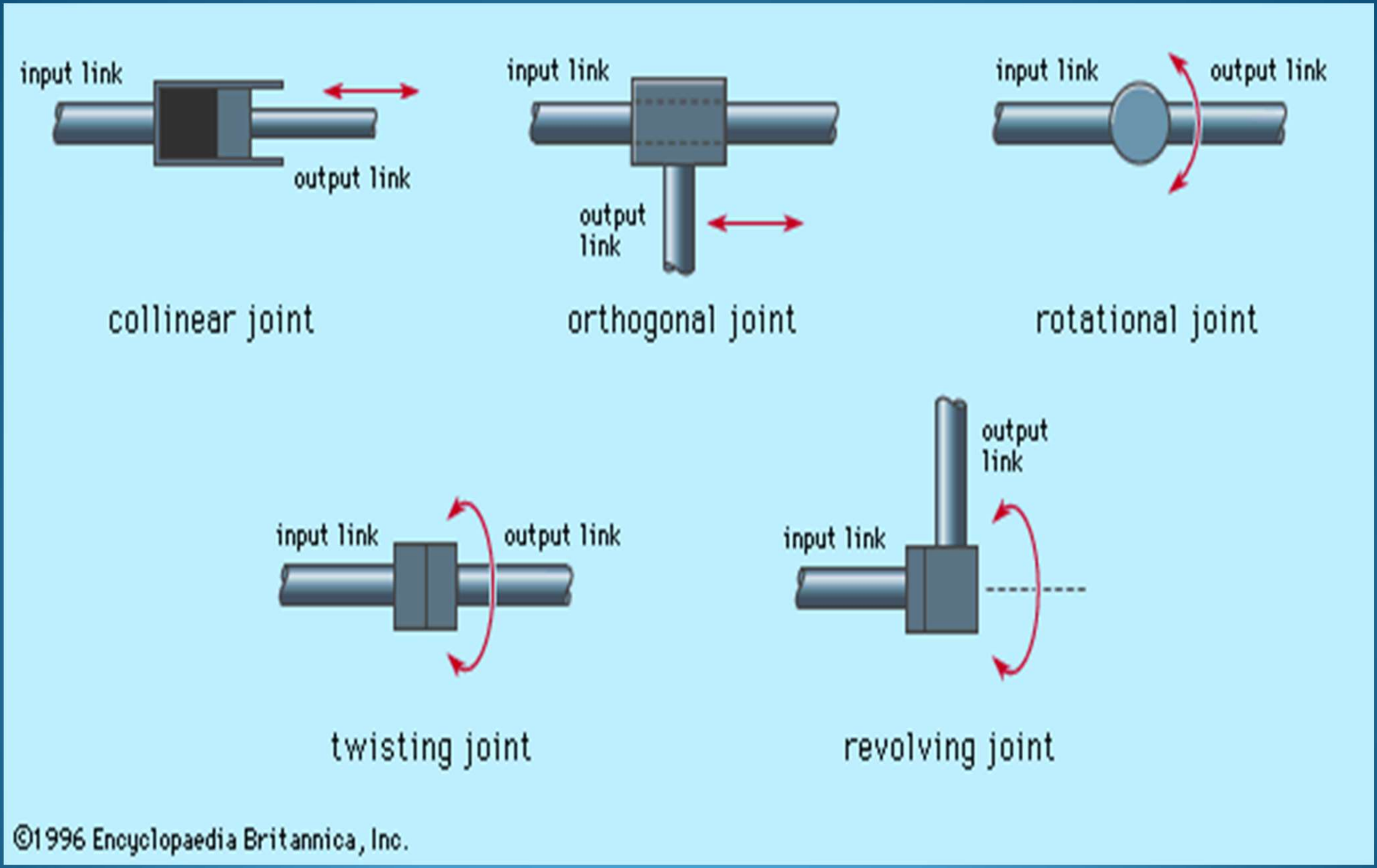
Source internet

Robot Anatomy



Robot manipulator - a series of joint-link combinations

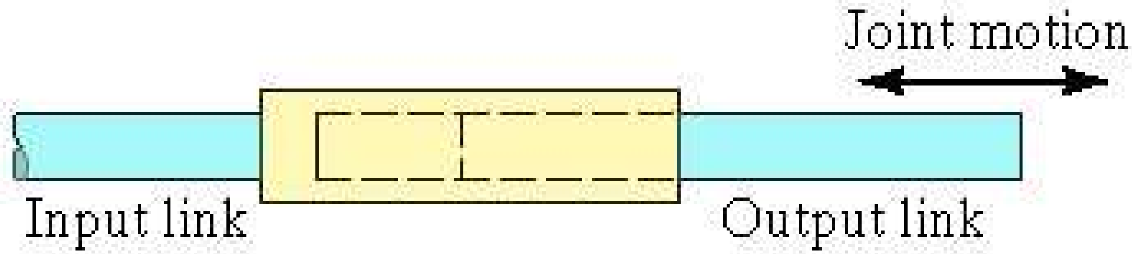
Industrial Robotics-Anatomy and related attributes



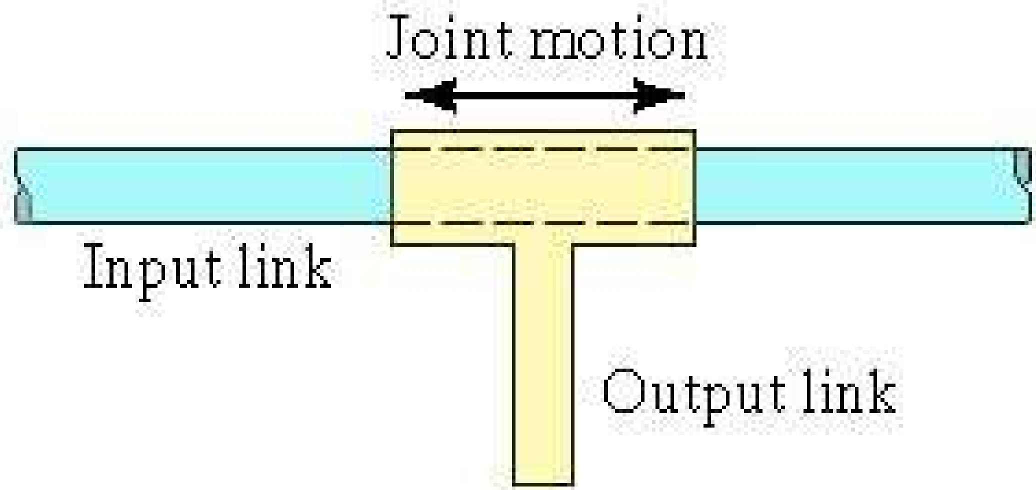
Five types of robot joints

Translational Motion Joints

Linear joint
(type L)

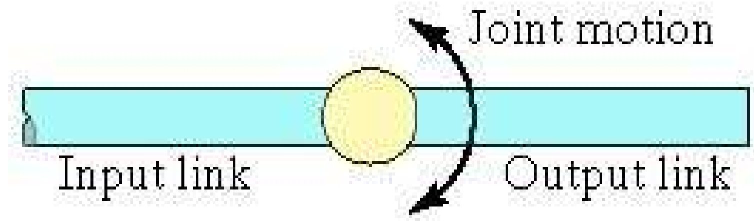


Orthogonal joint
(type O)

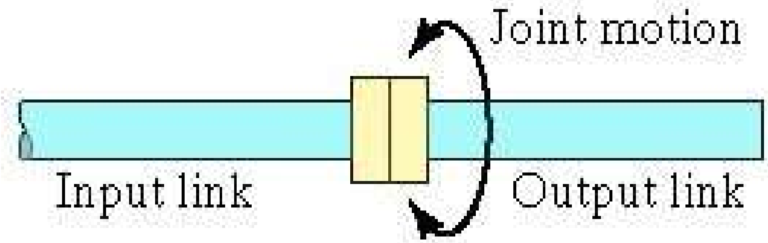


Rotary Motion Joints

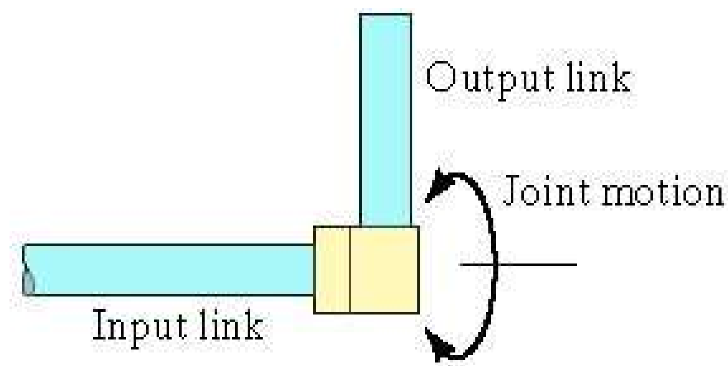
Rotational joint (type R)



Twisting joint (type T)



Revolving joint (type V)



Common Robot Configuration

Sections of a robot manipulator are

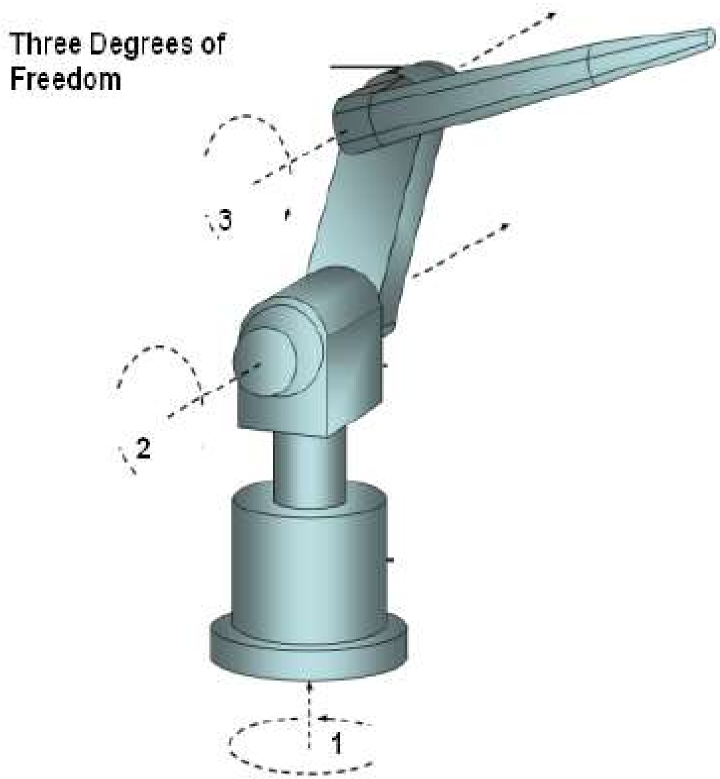
1) Body-and-arm assembly: position end-effector in space
2) Wrist assembly

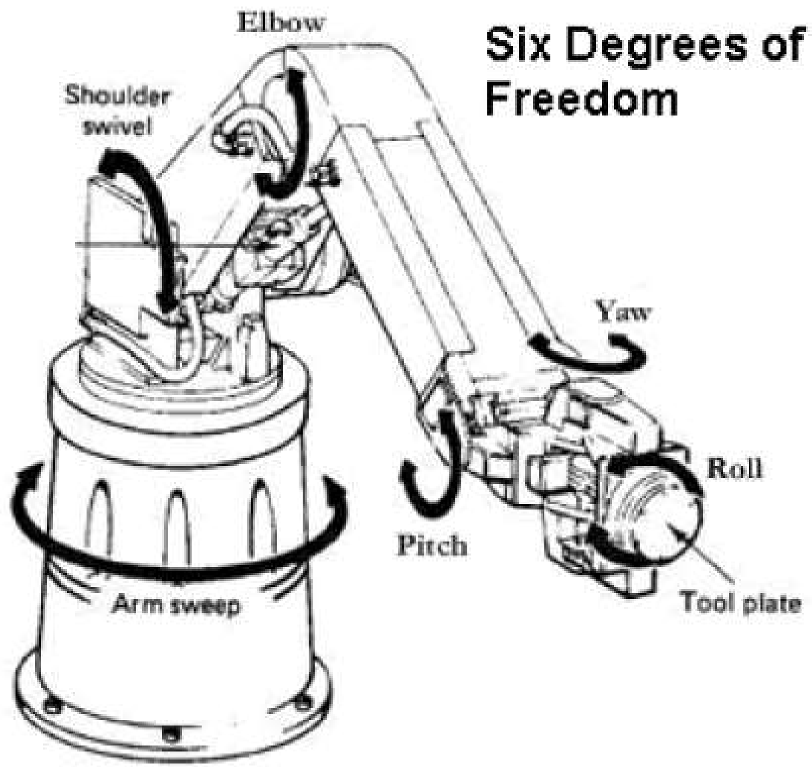
Body-and-arm configurations:

For a three-dof robot manipulator with the five common joints there will be 5x5x5= 125 different combinations of joints. However only five are used in commercial industrial robots:

1) Polar configuration
2) Cylindrical configuration
3) Cartesian coordinate robot
4) Jointed-arm robot and
5) SCARA (Selective Compliance Assembly Robot Arm)

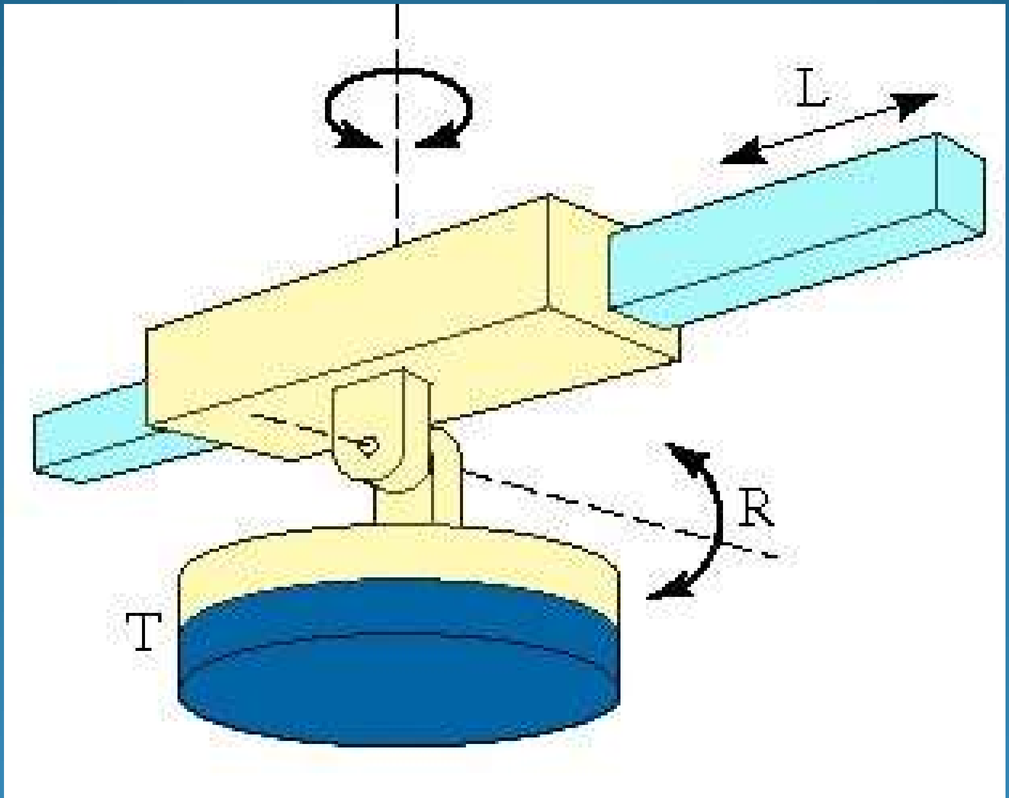
Degree of Freedom (DOF)





What is the DOF of your Arm?

Industrial Robotics-Body-and-arm configurations



Polar configuration

-Notation: TRL
-Sliding arm (L-joint) actuated relative to body
-Rotates about horizontal(R joint) and vertical axis (T joint).

Source: Ref. book

Industrial Robotics-Body-and-arm configurations

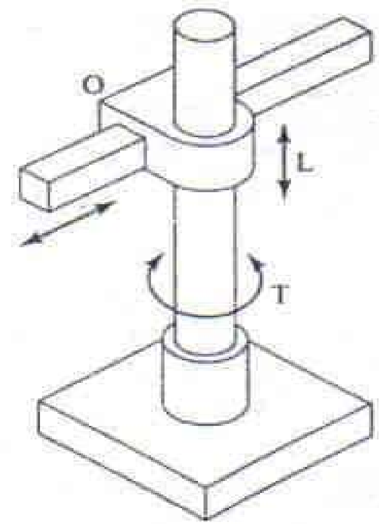


Figure 7.4 Cylindrical body-and-arm assembly.

Cylindrical configuration

-Notation: TLO
-An arm assembly moves up-and-down along a vertical column.
-arm can be moved in and out relative to column axis.
-Here a T-joint rotates the column and O-joint gives radial movement of the arm.

Source: Ref. book

Industrial Robotics-Body-and-arm configurations

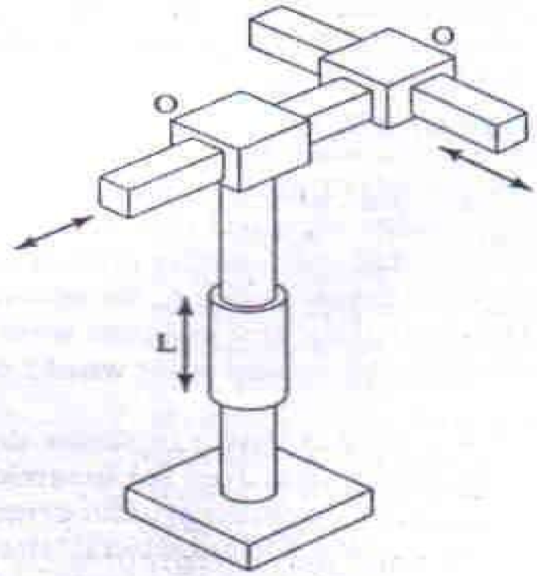


Figure 7.5 Cartesian coordinate body-and-arm assembly.

Cartesian coordinate robot

-Notation: LOO

-also called rectilinear or x-y-z robot.

-Composed of three sliding joints

Source: Ref. book

Industrial Robotics-Body-and-arm configurations

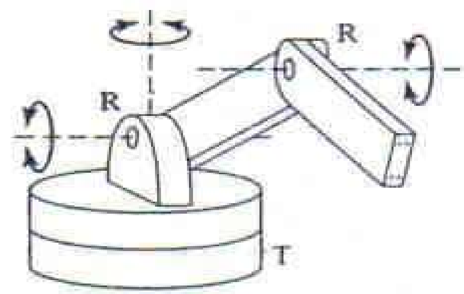


Figure 7.6 Jointed-arm body-and-arm assembly.

Jointed arm robot

-Notation: TRR

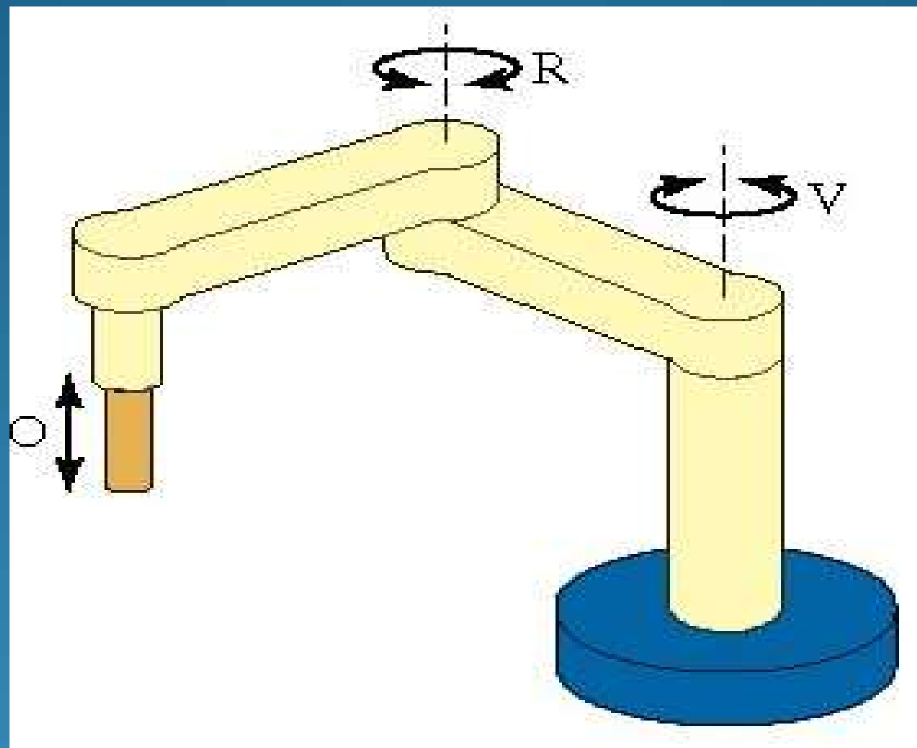
-a vertical column swivels about the base using T-joint.

-A shoulder joint (R joint) and

-Elbow joint (R joint)

Source: Ref. book

Industrial Robotics-Body-and-arm configurations



SCARA-Selective Compliance Assembly Robot Arm

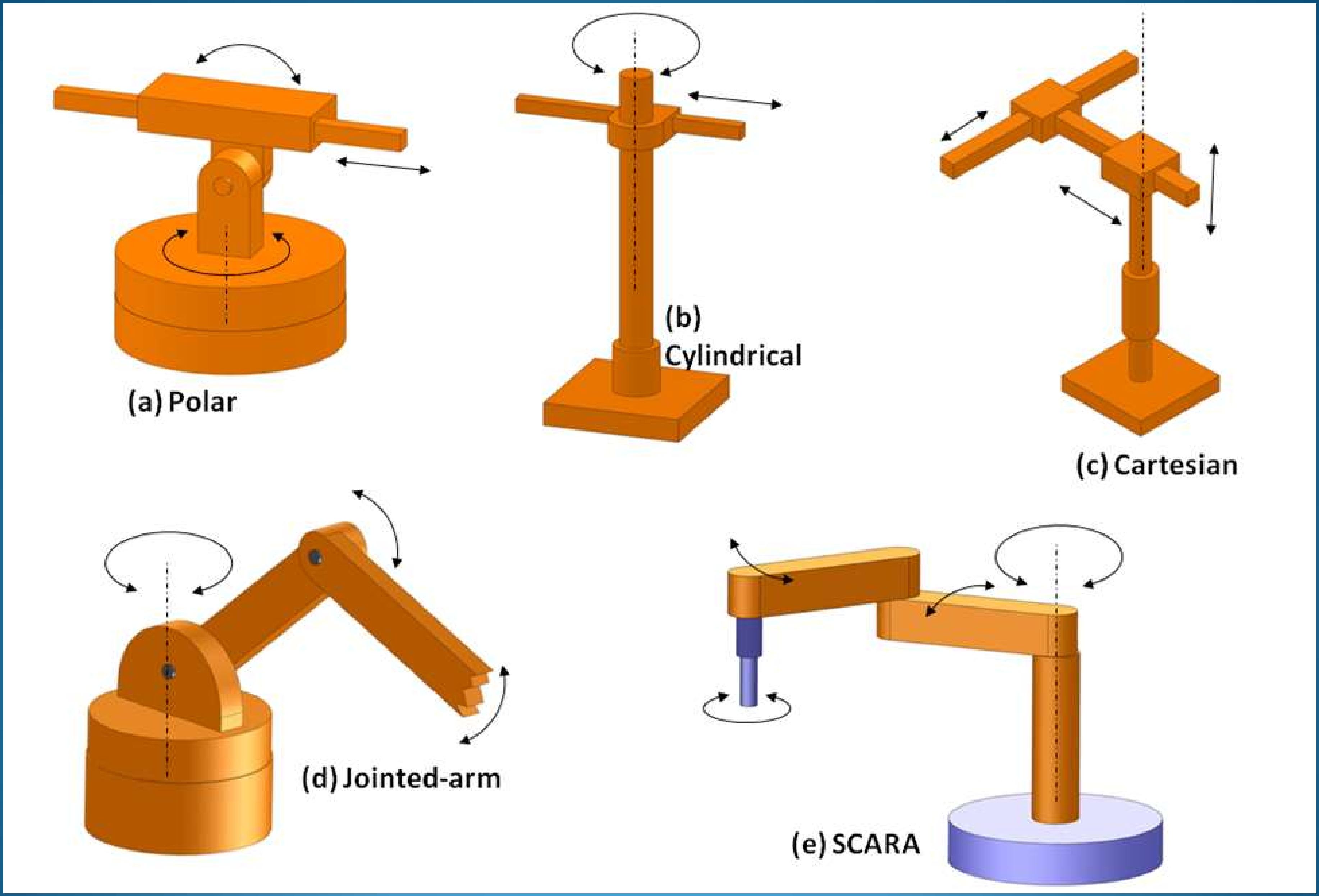
-Notation: VRO

-looks like jointed arm robot.

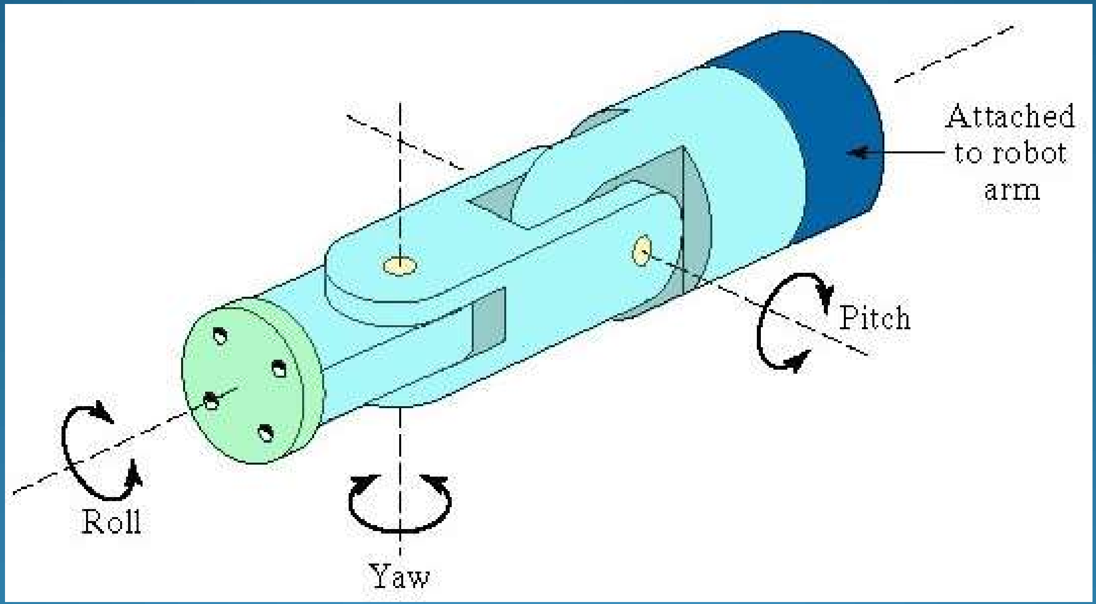
-but shoulder and elbow joints have vertical axis.

-very rigid and useful in insertion tasks.

Body-arm-assembly



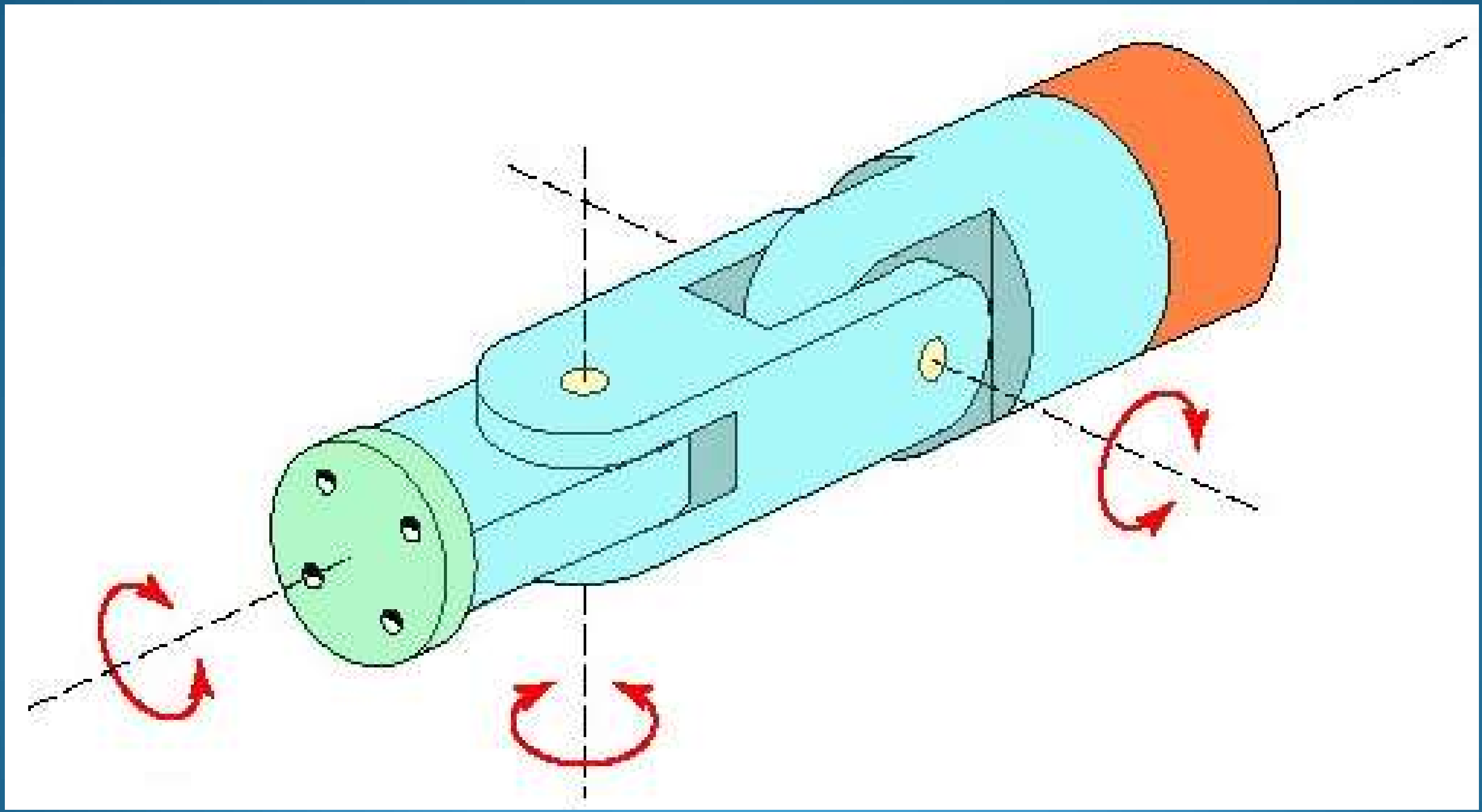
Wrist Assembly



Wrist assembly

-establishes the orientation of the end effectors.
-usually consists of three DOF.
-Roll-accomplishes rotation about the robot's arm axis. (T joint)
-Pitch-involves up-and-down rotation. (typically R joint)
-Yaw-involves right-and-left rotation. (typically R joint)

Wrist Assembly



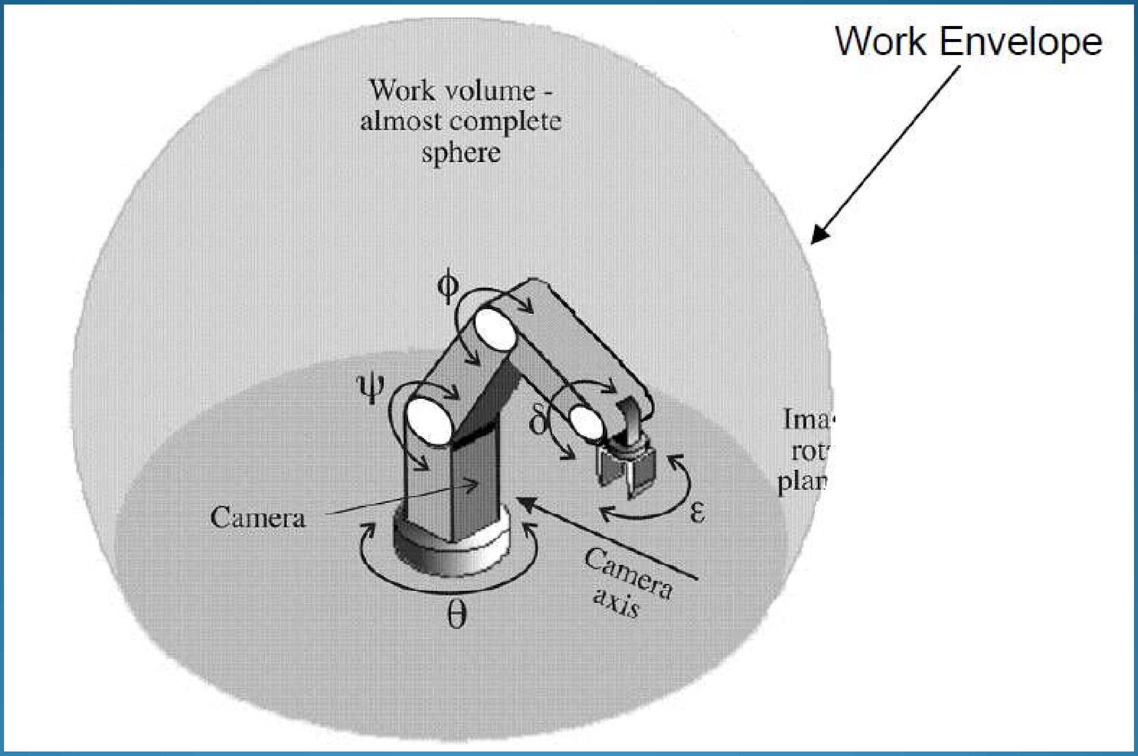
Joints notations

Joint Notation System

- Polar-TRL
- Cylindrical-TLO
- Cartesian coordinate-LOO
- Jointed arm-TRR
- SCARA-VRO

- Provide applications of such robots.

Work volume

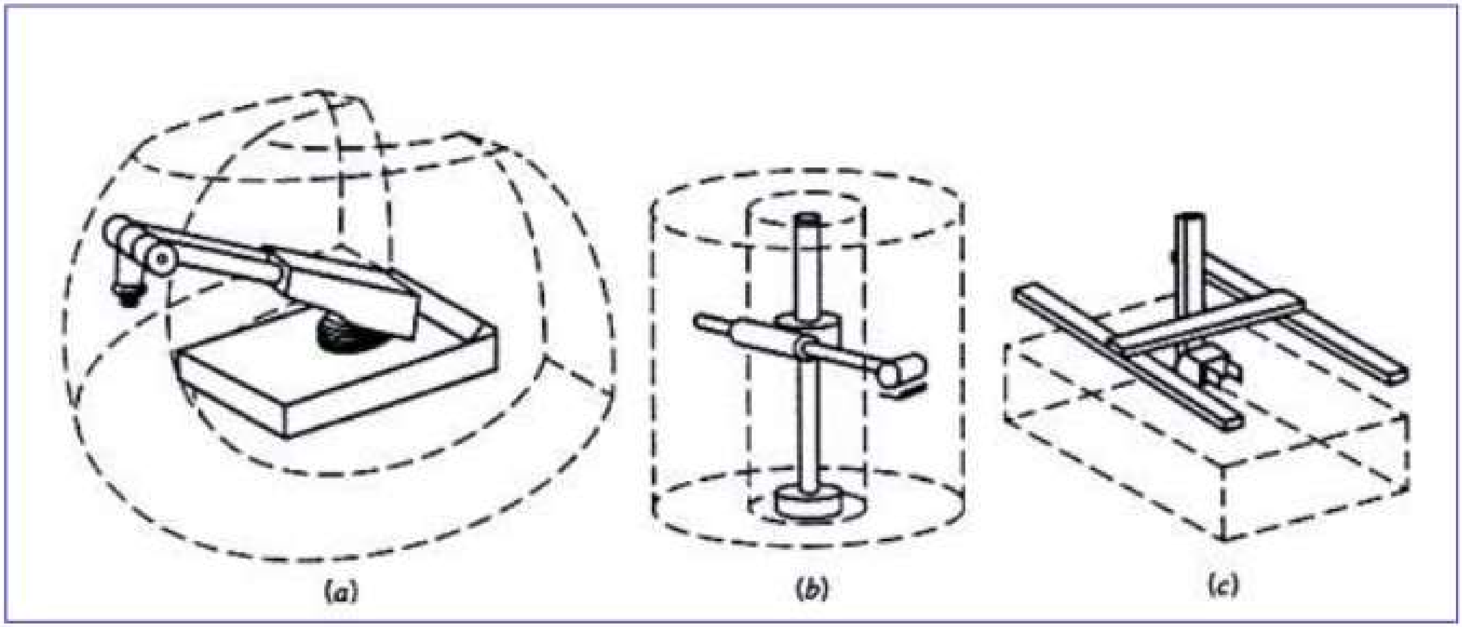


-also called work envelope.

-envelop or space within which the robot can manipulate the end of its wrist.

-determined by the number and types of joints, ranges of joints, physical size of the links.

Work volume



Robot reach (work envelope): **(a)** polar; (b) cylindrical robot; (c) Cartesian.

Joint Drive systems

Three types of drive systems are used to actuate joints:

1. Electric drive
2. Hydraulic drive and
3. Pneumatic drive

- Electric drive

  -uses electric motors like servo motor, stepping motor

  -used in sophisticated industrial robots

  -readily adaptable to computer control system.

  -relatively more accurate

Joint Drive systems

Joint Drive systems

- Hydraulic drive
  - uses linear piston and rotary vane
  - used in sophisticated industrial robots
  - has greater speed and strength
- Pneumatic drive
  - also uses linear piston and rotary vane
  - used in smaller robots, simple material transfer system.

Joint Drive systems

Dynamic response characteristics of manipulators depends on:

- Drive system,
- Position sensors and
- Feedback control system

Important factors in drive systems

- Speed (large robot has ~2m/sec)
- Acceleration and deceleration (0 to 60km/hr in 4sec for sports cars)
- Weight of the object
- Stability

Speed of response, stability

Control system

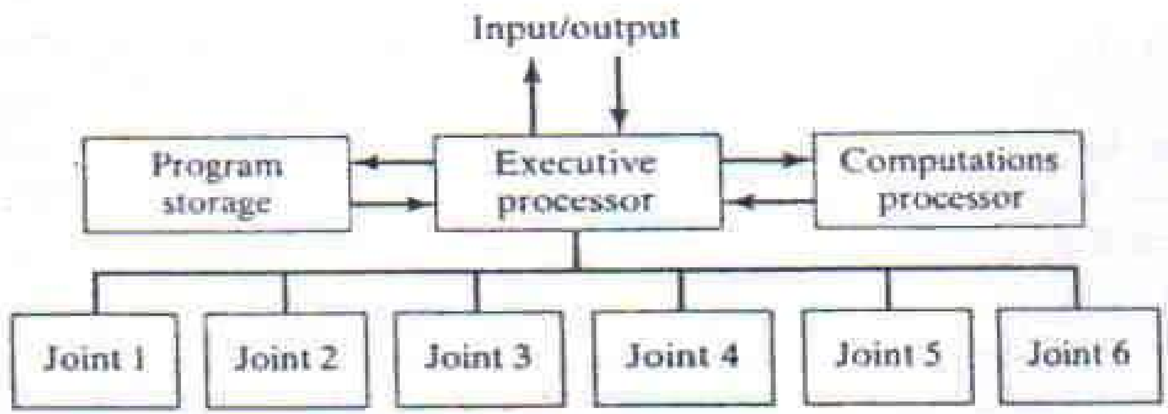


Figure 7.9 Hierarchical control structure of a robot microcomputer controller.

Controls individual joints in a coordinated fashion for the manipulator to perform a desired motion cycle.

-Microprocessor based

-Controller is organized in a hierarchical structure.

-each joint has its own feedback control system.

-supervisory controller coordinates the combined actuations of the joints

Types of Controller

- Limited sequence control
  -is used for simple motion cycles, such as pick and place
  -uses setting limits or mechanical stops
  -no servo control for precise positioning.

- Playback with point-to-point
  -memory records the sequence of motion
  -individual position of the robot arm are recorded in memory

- Playback with continuous path control
  -has greater storage and interpolation capacity
  -Servo control continuously regulate the position and speed

- Intelligent control
  -interact with environment, make decision, communicate etc.

End Effectors

End effectors are usually attached to robot's wrist, custom-engineered and fabricated for each different applications. Two categories of end effectors are:

- Grippers: grasp and manipulate object during work cycle.

  - Types are mechanical grippers, vacuum grippers, magnetized grippers, adhesive grippers, simple mechanical devices.

- Tools:
  - spot welding
  - arc welding
  - spray painting gun
  - rotating spindle for drilling, milling etc.
  - assemble tool
  - heating torch
  - water jet cutting tool.

Sensors

Sensors detects the physical variables of interest like temperature, pressure force etc.

- Internal sensors control position and velocity of various joints.
- External sensors coordinate the operation of robot with other equipment in the cell.

Some advanced sensors:

- Tactile sensors
- Proximity sensors
- Optical sensors
- Optical sensors
- Machine vision

Applications….. Cont.

Factors tend to promote the substitution of robots for human labor are:

- Hazardous work environment for humans
- Repetitive work cycle
- Difficult handling for humans
- Multishift operation
- Infrequent changeovers
- Part position and orientation are established in the work cell

Applications ..... Cont.

Applications can be classified in three categories:

- Material Handling
- Processing operations
- Assembly and inspection

Material Handling

Robot moves material from one place to another. Two situations for material handling are:

- Material transfer: primary purpose is to pick up a part at one location and place them at a new location. Basic applications are pick-and-place, palletizing and depalletizing.
- Machine loading and/or unloading: die casting, plastic molding, metal machining, forging, press working, heat treating

Applications ……cont.

Processing operations

Robot performs a processing operation on a workpart. Robot is equipped with tool as its end effector. Examples are:

- Spot welding
- Continuous arc welding
- Spray coating
- Other processing applications are
  - Drilling, routing and other machining operation
  - Grinding, wire brushing and similar operation
  - Water-jet cutting
  - Laser cutting
  - Riveting

Applications ….cont.

Processing operations

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Applications

Assembly and Inspection

-Combination of material handling and processing

-Assembly and inspection are labor intensive, highly repetitive and boring. So robot is more suitable.

-Most important application for assembly is where mixture of similar products/modules are produced in the same work cell.

-Inspection is necessary to ensure a given process has been completed, parts have been added as specified and to identify flaw in the raw materials or finished product.

-Part/finished product is placed in inspection or testing machine by robot or robot manipulate a inspection device to test the product

Industrial Robotics-Programming

Today three programming methods are used for industrial robots

- Lead through programming
- Computer like robot programming languages
- Off-line programming

Lead through programming

Task is taught to the robot by moving the manipulator through the required motion cycle, simultaneously entering the program into the controller memory for subsequent playback.

Two leadthrough programming are: powered lead through and manual lead through.

Powered lead through method uses teach pendant to move the robot arm at desired positions in sequence and record the position in memory.

Suitable for playback robots with point-to-point control.

Industrial Robotics-Programming

Lead through programming

Manual leadthrough is convenient for play back robot with continuous path control where the continuous path is an irregular motion pattern such as spray painting. Operator physically grasp the end of the arm, manually move it through the motion sequence, recording the path in the memory.

Teach Pendant>>>>

Industrial Robotics-Programming

Robot programming languages

Textual programming more popular because complex task can be easily programmed. It is also possible to embed logical decisions into the robot work cycle.

Compared to leadthrough programming textual languages

- Enhance sensor capabilities
- Improve output capabilities
- Allow to program logic
- Compute and process data
- Communicate with other computer system

Industrial Robotics-Programming

Robot programming languages

Textual statements are used for motion programming. Examples are:

MOVE P1

HERE P1

Off-line programming

No need to take the robot out of production. Allow to prepare the program in a remote place and then after simulation the program can be loaded into the memory.

Industrial Robotics-Programming

Industrial Robot Simulation

Homework: Make a list of robot simulators and compare them with each other

END

Of

Industrial Robotics