Ch 8 Industrial Robotics

Learning Objectives:

By the end of the lecture the student should be able to:

- Outline robot anatomy and related attributes.
- Explain robot control systems.
- Outline and explain end effectors.
- Outline and explain sensors in robotics.
- Provide industrial robot applications.
- Outline and explain different robot programming.
- Explain the terms of robot accuracy and repeatability.

Industrial Robot Defined

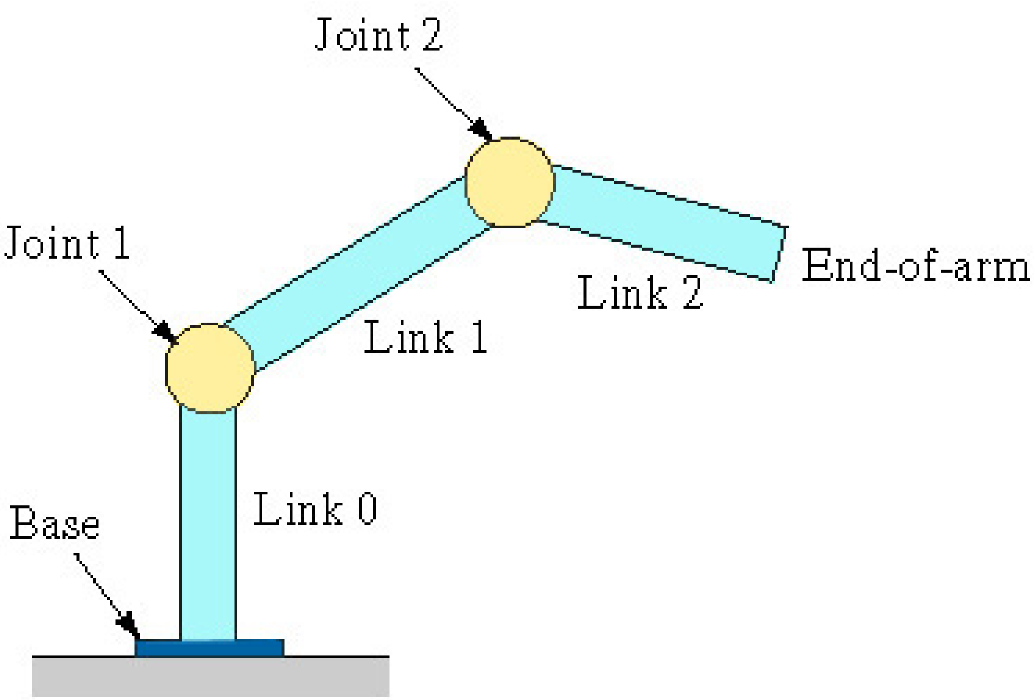
A general-purpose, programmable machine possessing certain anthropomorphic characteristics

- Why industrial robots are important:
  - Robots can substitute for humans in hazardous work environments
  - Consistency and accuracy not attainable by humans
  - Can be reprogrammed
  - Most robots are controlled by computers and can therefore be interfaced to other computer systems

Robot Anatomy

- Manipulator consists of joints and links
  - Joints provide relative motion
  - Links are rigid members between joints
  - Various joint types: linear and rotary
  - Each joint provides a "degree-of-freedom"
  - Most robots possess five or six degrees-of-freedom
- Robot manipulator consists of two sections:
  - Body-and-arm – for positioning of objects in the robot's work volume
  - Wrist assembly – for orientation of objects

Robot Anatomy



Robot manipulator - a series of joint-link combinations

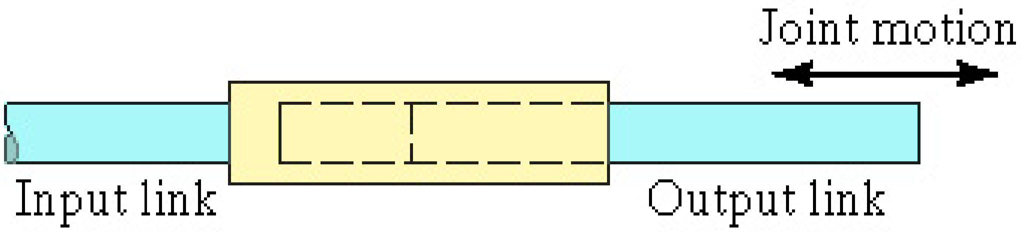
Types of Manipulator Joints

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

Translational Motion Joints

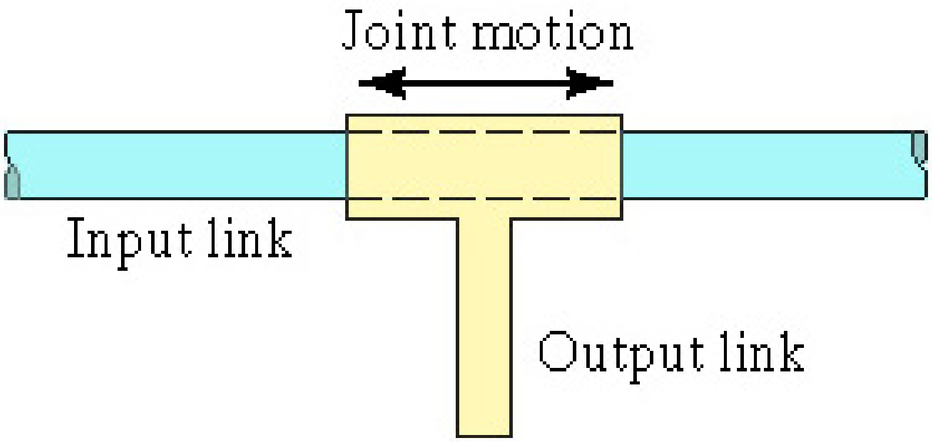
Linear joint

(type L)



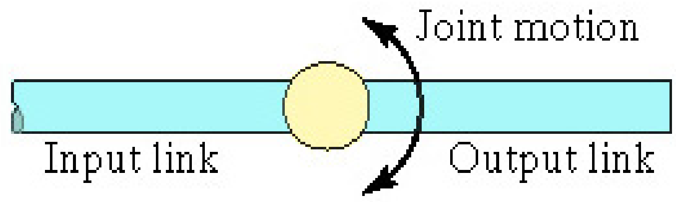
Orthogonal joint

(type O)

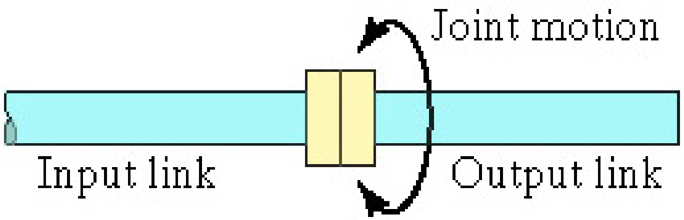


Rotary Motion Joints

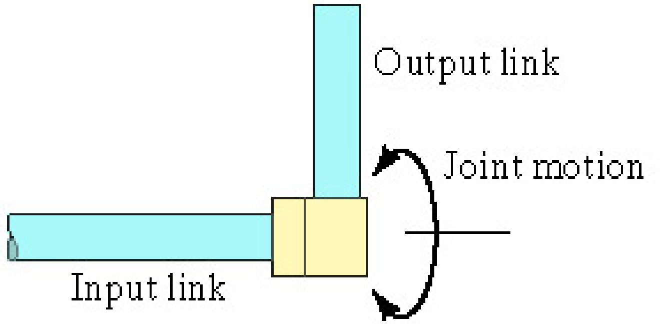
Rotational joint
(type R)



Twisting joint
(type T)



Revolving joint
(type V)

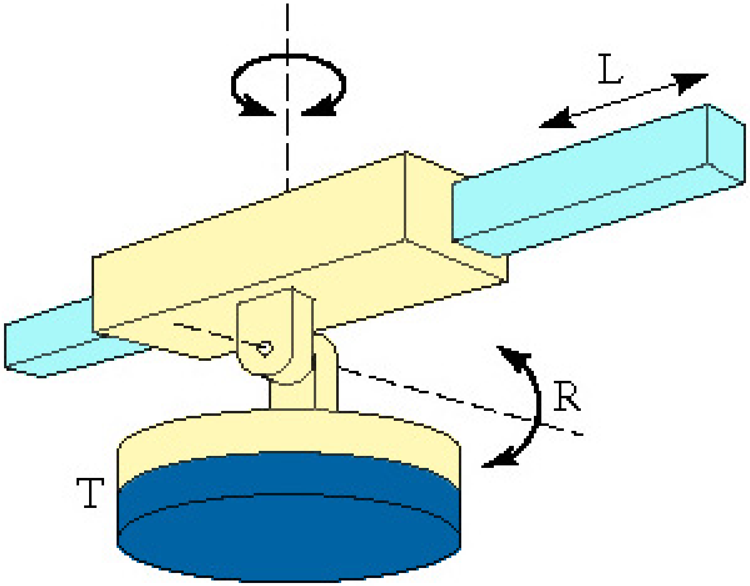


Robot Body-and-Arm Configurations

- Five common body-and-arm configurations for industrial robots:
  1. Polar coordinate body-and-arm assembly
  2. Cylindrical body-and-arm assembly
  3. Cartesian coordinate body-and-arm assembly
  4. Jointed-arm body-and-arm assembly
  5. Selective Compliance Assembly Robot Arm (SCARA)
- Function of body-and-arm assembly is to position an end effector (e.g., gripper, tool) in space

Polar Coordinate Body-and-Arm Assembly

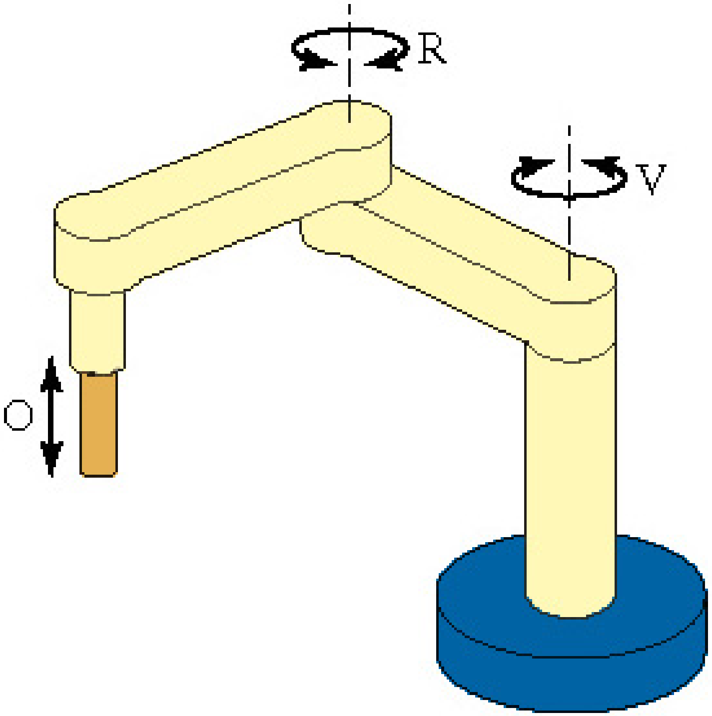
- Notation TRL:



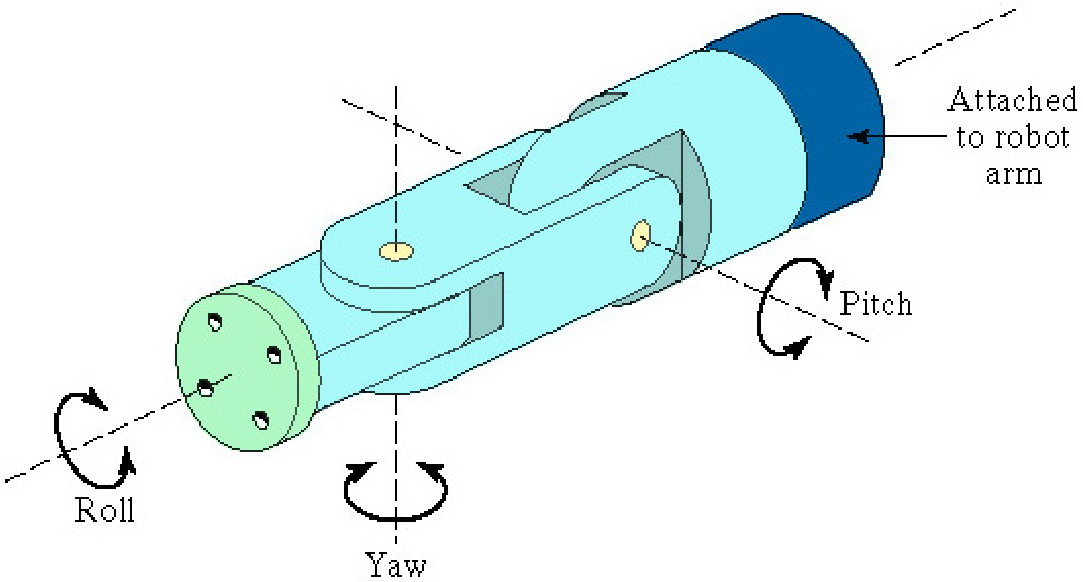
- Consists of a sliding arm (L joint) actuated relative to the body, which can rotate about both a vertical axis (T joint) and horizontal axis (R joint)

SCARA Robot

- Notation VRO
- SCARA stands for Selectively Compliant Assembly Robot Arm
- 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



Wrist Configuration



- Typical wrist assembly has two or three degrees-of-freedom (shown is a three degree-of freedom wrist)
- Notation :RRT

Joint Drive Systems

- Electric
  - Uses electric motors to actuate individual joints
  - Preferred drive system in today's robots
- Hydraulic
  - Uses hydraulic pistons and rotary vane actuators
  - Noted for their high power and lift capacity
- Pneumatic
  - Typically limited to smaller robots and simple material transfer applications

Robot Control Systems

- Playback with point-to-point control – records work cycle as a sequence of points, then plays back the sequence during program execution
- Playback with continuous path control – greater memory capacity and/or interpolation capability to execute paths (in addition to points)
- Intelligent control – exhibits behavior that makes it seem intelligent, e.g., responds to sensor inputs, makes decisions, communicates with humans

End Effectors

- The special tooling for a robot that enables it to perform a specific task
- Two types:
  - Grippers – to grasp and manipulate objects (e.g., parts) during work cycle
  - Tools – to perform a process, e.g., spot welding, spray painting

Robot Application Characteristics

General characteristics of industrial work situations that promote the use of industrial robots

1. Hazardous work environment for humans
2. Repetitive work cycle
3. Difficult handling task for humans
4. Multishift operations
5. Infrequent changeovers
6. Part position and orientation are established in the work cell

Industrial Robot Applications

1. Material handling applications
   - Material transfer – pick-and-place, palletizing
   - Machine loading and/or unloading
2. Processing operations
   - Spot welding and continuous arc welding
   - Spray coating
   - Other – waterjet cutting, laser cutting, grinding
3. Assembly and inspection

Robot Programming

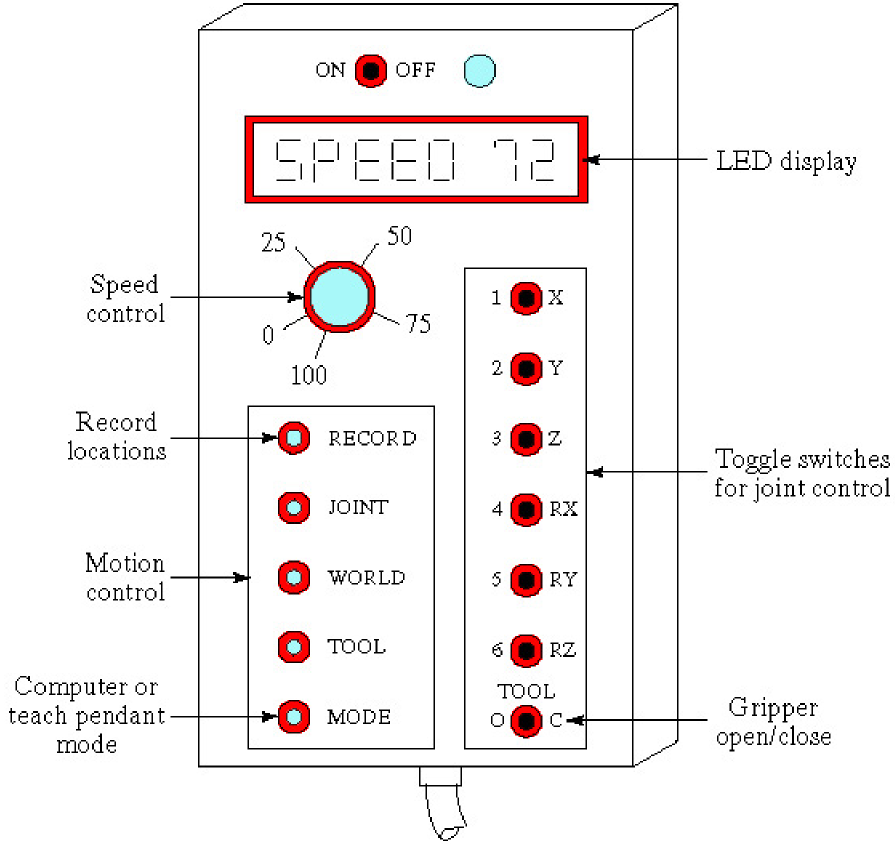
- Leadthrough programming - work cycle is taught to robot by moving the manipulator through the required motion cycle and simultaneously entering the program into controller memory for later playback
- Robot programming languages - uses textual programming language to enter commands into robot controller
- Simulation and off-line programming – program is prepared at a remote computer terminal and downloaded to robot controller for execution without need for leadthrough methods

Leadthrough Programming

Two types:

1. Powered leadthrough
   - Common for point-to-point robots
   - Uses teach pendant to move joints to desired position and record that position into memory
2. Manual leadthrough
   - Convenient for continuous path control robots
   - Human programmer physical moves manipulator through motion cycle and records cycle into memory

Teach Pendant for Powered Leadthrough Programming



Robot Accuracy and Repeatability

Three terms used to define precision in robotics, similar to numerical control precision:

1. Control resolution - capability of robot's positioning system to divide the motion range of each joint into closely spaced points
2. Accuracy - capability to position the robot's wrist at a desired location in the work space, given the limits of the robot's control resolution
3. Repeatability - capability to position the wrist at a previously taught point in the work space