Robotics

Introduction:

Introduction to Robotics is a branch of engineering and science that includes electronics engineering, mechanical engineering, computer science, and so on. Robotics deals with the design, construction, use to control robots, sensor feedback, and information processing. Robotics courses are spread across mechanical engineering, electrical engineering, and computer science. Robotics courses cover topics such as robotics foundations in kinematics, dynamics, control, motion planning, trajectory generation, programming, and design. Robotics courses also include planar and spatial kinematics, and motion planning; mechanism design for manipulators and mobile robots, multi-rigid-body dynamics, 3D graphic simulation; control design, actuators, and sensors; wireless networking, task modeling, human-machine interface, and embedded software.

Need for Robotics in Automation industries:

The use of robotics in the automation industry has become increasingly popular in recent years. Here are some reasons why robotics is essential in the automation industry:

1. Boosted Productivity and Efficiency: Robotics can perform repetitive tasks faster and more accurately than humans, leading to increased productivity and efficiency.

2.Enhanced System Flexibility: Robots can be programmed to perform a variety of tasks, making them more flexible than traditional automation systems.

3. Upgraded Product Quality: Robots can perform tasks with high precision and accuracy, resulting in improved product quality.

4. Increased Cost Savings: Robotics can reduce labor costs and increase throughput, leading to cost savings for manufacturers.

5. Elevated Safety: Robots can perform tasks that are hazardous to humans, improving safety in the workplace.

6. Addressing the Skills Gap: Robotics can help address the skills gap by performing tasks that require specialized skills or are dangerous for humans.

7. Improved Uptime: Robots can work non-stop for 24 hours, unattended, every single day, leading to increased production.

8. Customization: Robotics can be customized to meet specific manufacturing needs, making them more versatile than traditional automation systems.

9. Integration with Advanced Technology: Robotics can be integrated with advanced technologies such as machine learning, computer vision, and the Internet of Things, leading to improved performance and efficiency.

10. Competitive Advantage: Robotics can give manufacturers a competitive advantage by improving

productivity, quality, and efficiency, leading to increased profitability.

Types Of Robotics:

The Different Types Of Robots

- Industrial Robots: These robots are used in manufacturing and perform tasks such as welding, painting, and assembly.
- Autonomous Mobile Robots (AMRs): These robots are used for material handling and transportation in warehouses and factories.
- Articulated Robots: These robots are the most common type of industrial robot and are used for tasks such as welding, painting, and assembly.
- Humanoid Robots: These robots are designed to resemble humans and are used for research, entertainment, and education.
- Medical Robots: These robots are used in the medical field for tasks such as surgery, rehabilitation, and diagnosis.
- Exploration Robots: These robots are used for space exploration, deep-sea exploration, and other hazardous environments.
- Consumer Robots: These robots are designed for personal use and include robots for cleaning, entertainment, and education.
- 10. Teleoperated Robots: These robots are controlled remotely by a human operator and are used in hazardous environments such as nuclear power plants and deep-sea exploration.

- Telerobots: These robots have semi-autonomous behavior and are controlled remotely by a human operator.
- Construction Robots: These robots are used in the construction industry for tasks such as bricklaying, concrete spraying, and demolition.
- Agricultural Robots: These robots are used in agriculture for tasks such as planting, harvesting, and monitoring crops.
- Chatbots: These bots carry out simple conversations, often in a customer service setting.
- Spam Bots: These bots collect email addresses and send spam mail.

Overall, there are many different types of robots, each designed to perform specific tasks in various fields such as manufacturing, healthcare, exploration, and entertainment.

Work Volume

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

1. The robot's physical configuration, including the type of joints and the number of axes (degree of freedom).

2. The ranges of various joints, which determine the robot's range of motion.

3. The physical size of the links, which affects the robot's ability to reach into tight spaces.

4. The shape of the robot's configuration, which determines the shape of the work volume.

The actual shape of the work volume is dependent on the robot's configuration. For example:

1.Polar robotic configuration tends to produce a spherical work volume.

2.A cylindrical configuration has a cylindrical work volume.

3.Cartesian coordinate robot produces a rectangular work volume.

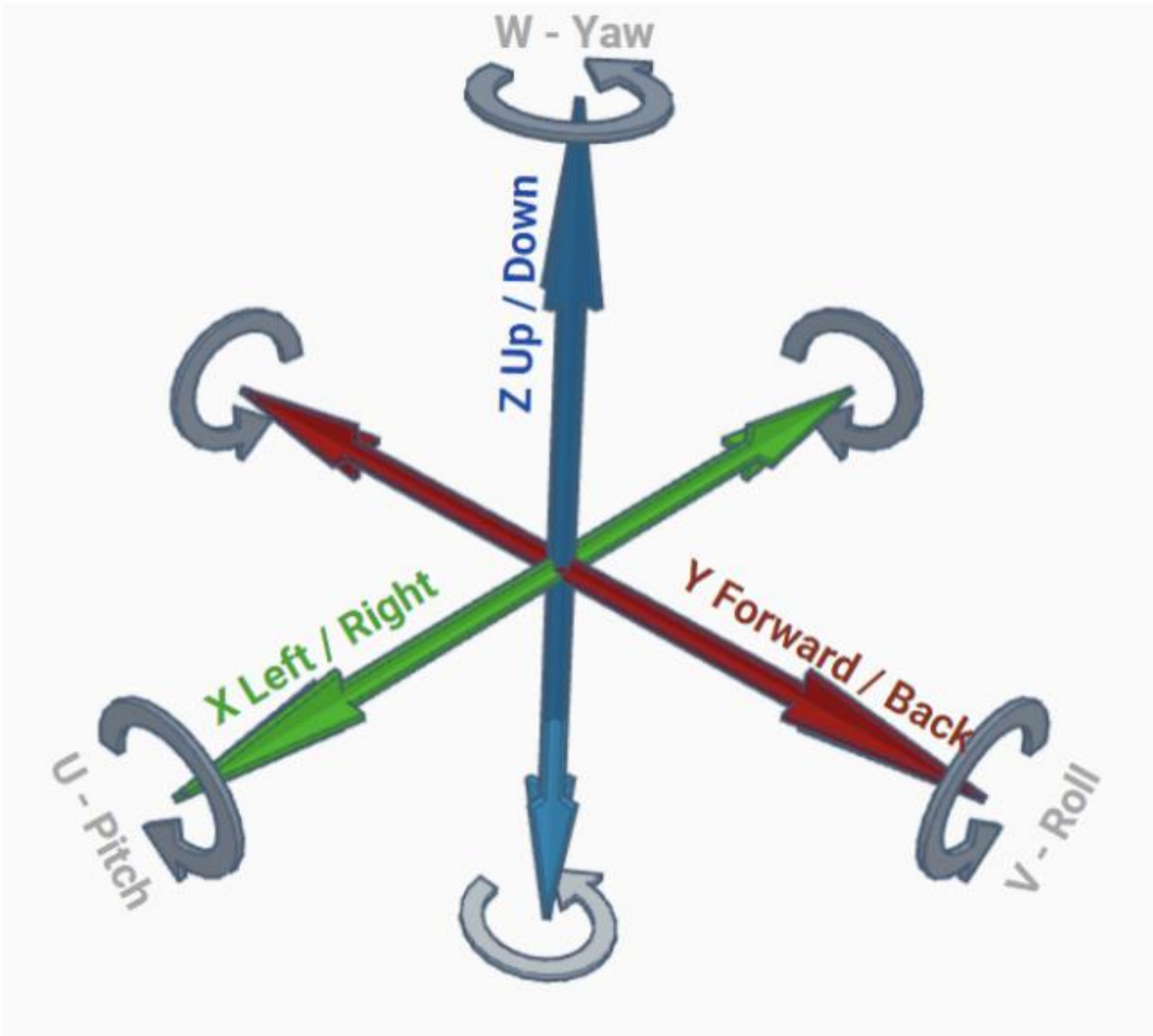
The work volume is the three-dimensional space in which the robot can manipulate the end of its wrist. The work envelope or volume is an important consideration when selecting a robot for a specific task, as it determines the range of motion and the size of the objects that the robot can handle. There are various methods to compute the workspace volume of a robot, including numerical integration

Degree-of-Freedom

The degree of freedom is an extremely important factor in robotics that is used to define the physical motion capabilities of a robot. A robot is essentially a combination of multiple mechanisms where each mechanism is formed by a set of links and joints

The 6 degrees of freedom are controlled through translation. Translation is an object’s movement in a 3D space in the Z axis (up and down), X axis (left and right), and Y axis (forward and back).

The linear translation degrees of freedom are controlled by defining the origin or the datum reference frame, which should all be perpendicular to one another respectively.



The Six Degrees Of Freedom In Robotics:

1. Forward/Back: This degree of freedom refers to the linear movement of an object along the Z-axis, which is forward and backward.

2. Up/Down: This degree of freedom refers to the linear movement of an object along the Y-axis, which is up and down.

3. Left/Right: This degree of freedom refers to the linear movement of an object along the X-axis, which is left and right.

4. Pitch: This degree of freedom refers to the rotational movement of an object around the X-axis, which is tilting up and down.

5. Yaw: This degree of freedom refers to the rotational movement of an object around the Z-axis, which is turning left and right.

6. Roll: This degree of freedom refers to the rotational movement of an object around the Y-axis, which is tilting left and right.

These six degrees of freedom are used to describe the movement of a rigid body in three-dimensional space. They are important considerations when designing and selecting robots for specific tasks, as they determine the range of motion and the size of the objects that the robot can handle.

Refer:

https://youtu.be/fc_Cynqr6jM

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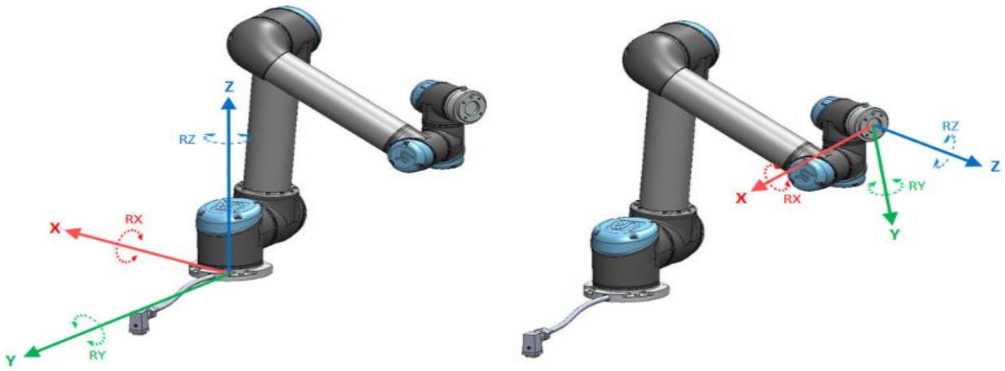
ROBOTIC JOINT

A robot joint is a mechanism that permits relative movement between parts of a robot arm. The joints of a robot are designed to enable the robot to move its end-effector along a path from one position to another as desired. The basic movements required for a desired motion of most industrial robots are:

- Rotational movement: This enables the robot to place its arm in any direction on a horizontal plane.
- Radial movement: This enables the robot to move its end-effector radially to reach distant points.
- Vertical movement: This enables the robot to take its end-effector to different heights.



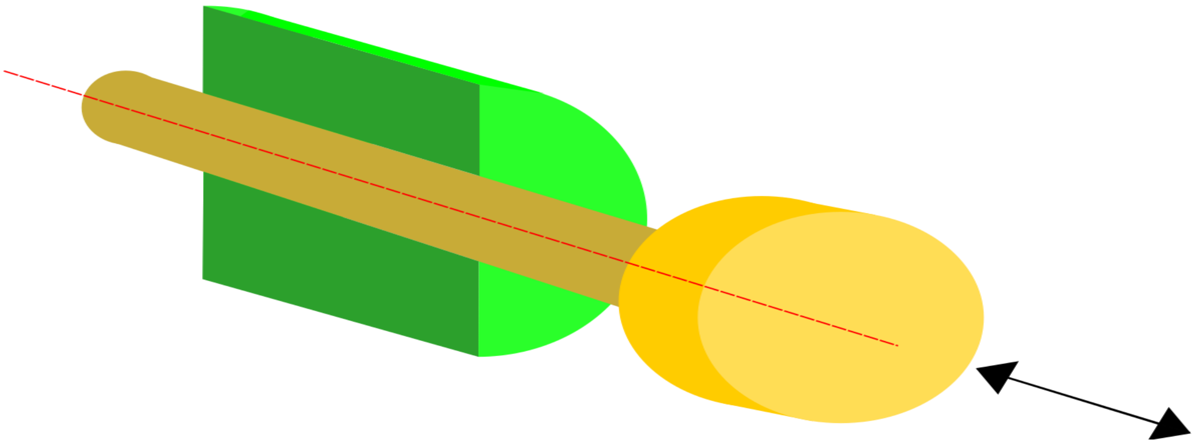
Degrees of freedom, independently or in combination with others, define the complete motion of the endeffector. These motions are accomplished by movements of individual joints of the robot arm. The joint movements are basically the same as relative motion of adjoining links.

Classification of Joints

- Prismatic joints
- Revolute joints

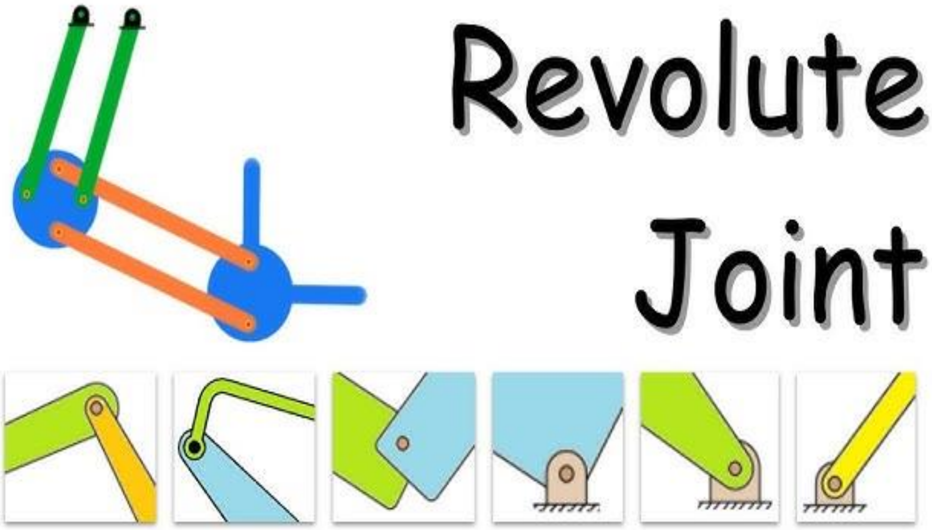
Prismatic joints:

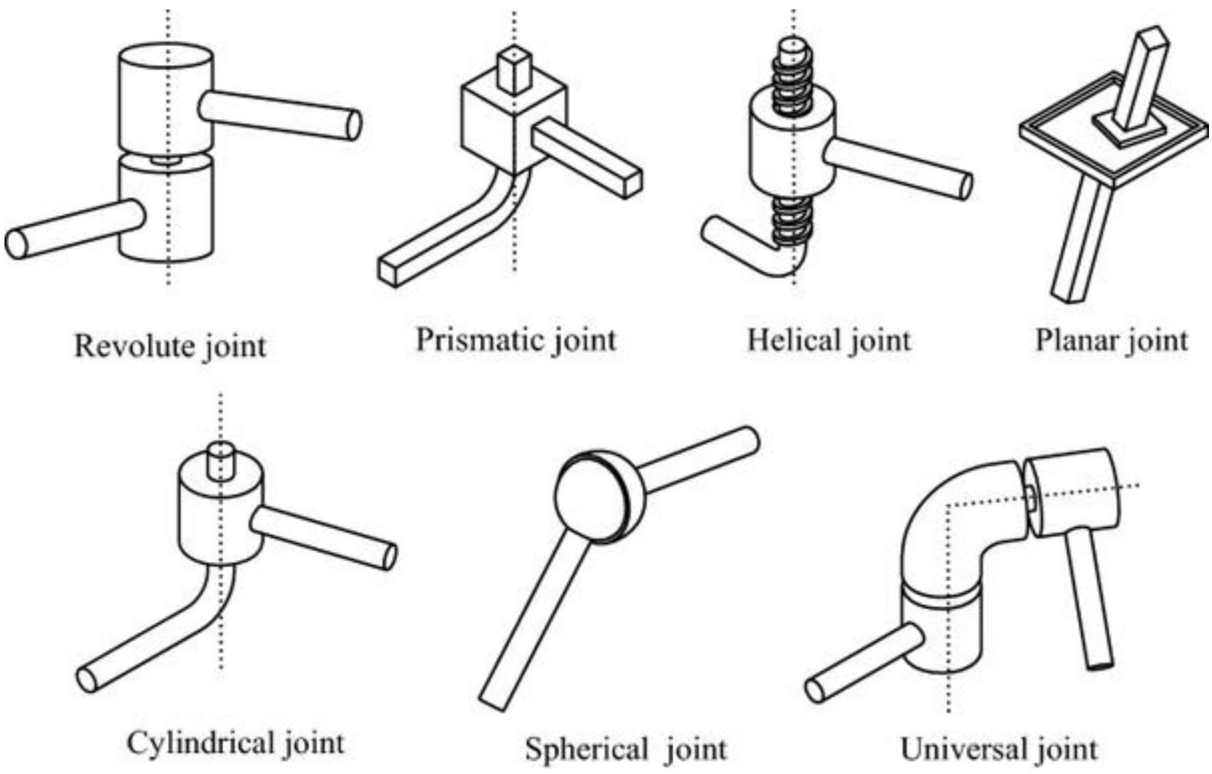
Prismatic joints are also known as sliding as well as linear joints. They are called prismatic because the cross section of the joint is considered as a generalized prism. They permit links to make a linear displacement along a fixed axis. In other words, one link slides on the other along a straight line. These joints are used in gantry, cylindrical, or similar joint configurations.



- **Revolute joints**

Revolute joints, the second type of joint is a revolute joint where a pair of links rotates about a fixed axis. Revolute joints are commonly used in assemblies of multiple moving bodies. They are also used in numerous applications such as door hinges, mechanisms, and other uni-axial rotation devices





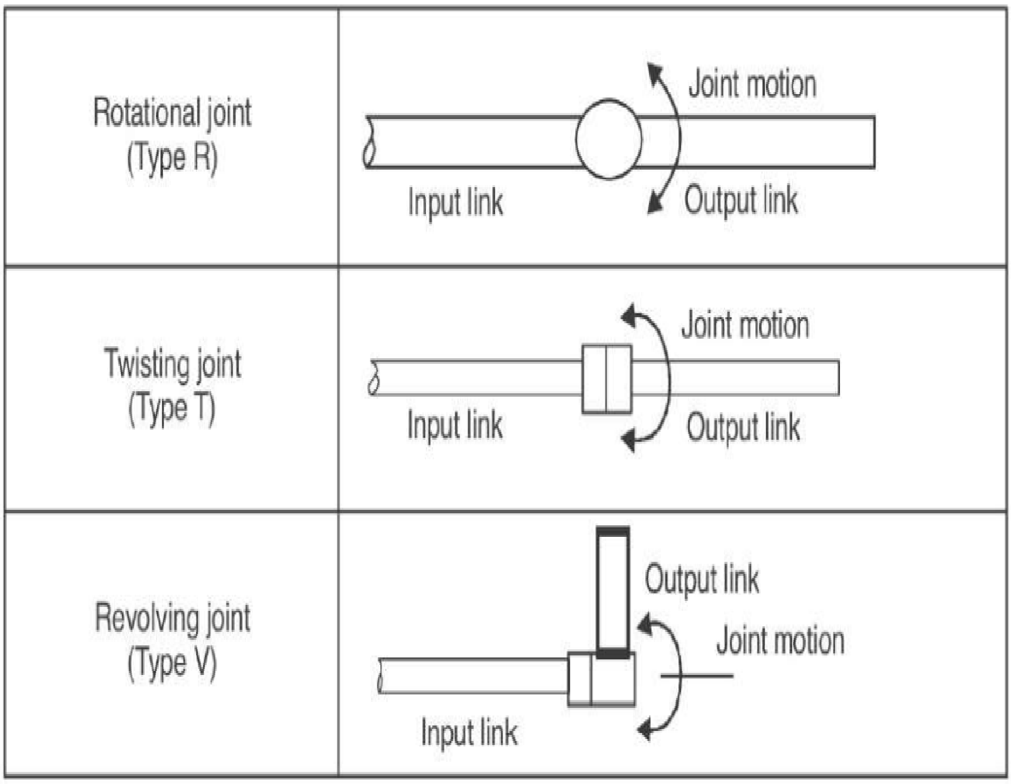
The variations of revolute joints shown include:

- Rotational joint (R)
- Twisting joint (T)
- Revolving joint (V)

Rotational joint (R): Is identified by its motion, rotation about an axis perpendicular to the adjoining links. Here, the lengths of adjoining links do not change but the relative position of the links with respect to one another changes as the rotation takes place.

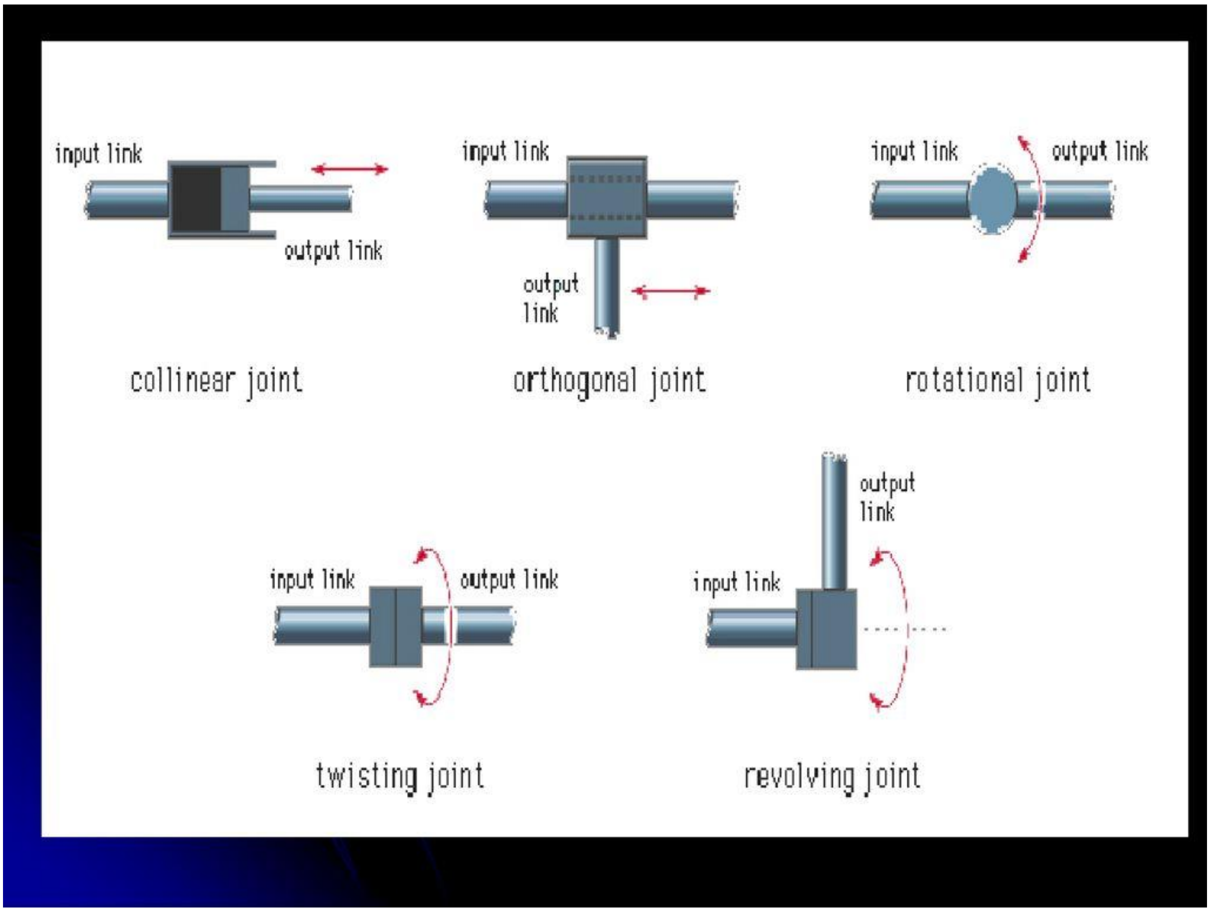
Twisting Joint (T):Is also a rotational joint, where the rotation takes place about an axis that is parallel to both adjoining links.

Revolving Joint (V): is another rotational joint, where the rotation takes place about an axis that is parallel to one of the adjoining links. Usually, the links are aligned perpendicular to one another at this kind of joint. The rotation involves revolution of one link about another.



Types Of Mechanical Joints

- 1.Linear joint(L joint): A linear joint is not a commonly used term in robotics or mechanical engineering. However, a prismatic joint allows for linear relative motion between two links. It is a one-degree-of-freedom kinematic pair that constrains the motion of two bodies to sliding along a common axis, without rotation. Prismatic joints are often utilized in hydraulic and pneumatic cylinders.
- 2.Orthogonal joint(O joint): An orthogonal joint provides rotational relative motion with the axis of rotation perpendicular to the axis of the input and output links.
- 3.Rotational joint(R joint): A rotational joint allows two 3-dimensional bodies to rotate relative to each other about a fixed axis and permits no other relative motion. It is, by far, the most common type of joint in robotics
- 4.Twisting joint(T joint): Twisting joint is not a commonly used term in robotics or mechanical engineering. However, screw joint allows relative rotation and translation between two links.
- 5.Revolving joint(V joint): A revolute joint is like a hinge and and allows relative rotate between two links.


input link
output link
collinear joint
input link
output link
orthogonal joint
input link
output link
rotational joint
output link
input link
output link
input link
twisting joint
revolving joint

SENSOR CLASSIFICATION

The major capabilities required by a robot are as follows:

- Simple Touch The presence or absence of an object.
- Taction or Complex Touch The presence of an object plus some information on its size and shape.
- Simple Force Measured force along a single axis.
- Complex Force Measured force along two or more axes.
- Proximity Noncontact detection of an object.
- Simple Vision Detection of edges, holes, corners, and so on
- Complex Vision Recognition of shapes.

TYPES OF SENSORS USED IN ROBOTICS

1) TACTILE SENSORS: Tactile Sensor is a device specifying an object's contact. Often used in everyday objects such as elevator buttons and lamps, which dim or brighten by touching the base, a tactile sensor allows the robot to touch and feel. These sensors are used to measure applications and gently interact with the environment.

   It can be sorted two principal types: Touch Sensor And Force Sensor.

- Touch Sensor Or Contact Sensor: Touch Sensor is capable of sensing and detecting sensor and object touch. Some of the commonly used simple devices are micro-switches, limit switches, etc. These sensors are mostly used for robots to avoid obstacles. When these sensors hit an obstacle, it triggers a task for the robot, which can be reversed, turned, switched on, stopped, etc.
- Force Sensor: Force sensor is included in calculating the forces of several functions, such as machine loading & unloading, material handling, and so on, performed by a robot. This sensor will also be a better assembly process to check problems.
- Light sensors: There are different types of light sensors used in robot parts, such as photoresistors, photovoltaic cells, CCDs, and

phototubes. These sensors detect changes in light intensity and can be used for object detection, line following, and color recognition

- Sound sensors: These sensors detect sound waves and can be used for speech recognition, noise detection, and vibration analysis
- Temperature sensors: These sensors measure temperature changes and can be used for temperature control, object detection, and fire detection.
- Contact sensors: These sensors detect physical contact between the robot and objects in its environment. They can be used for collision detection, object recognition, and force sensing.
- Proximity sensors: These sensors detect the presence of objects in the robot's vicinity and can be used for obstacle avoidance, object detection, and position sensing.
- Vision sensors: These sensors capture visual data and can be used for object recognition, tracking, and inspection. Two-dimensional and three-dimensional visual sensors are commonly used in industrial robots.

APPLICATIONS

• Patient monitoring in medical applications: Temperature sensors are used to monitor the patient temperature in medical facilities.

• Aerospace Applications: Position sensors are used for wing flap position measurement as well as other applications integral to the safety of passengers.

• Motorsport Applications: Monitoring fuel, gas, tyre and oil pressure within motorsport vehicles. We have a range of combined pressure and temperature transducers which are perfect for motorsport applications as they are very compact for these tight environments.

• Manufacturing and industrial equipment : Temperature sensors are used within machines to ensure they do not overheat and become unsafe.

• Agriculture Applications – Steering systems in agricultural machinery use both rotary and linear position sensors.

END EFFECTOR:

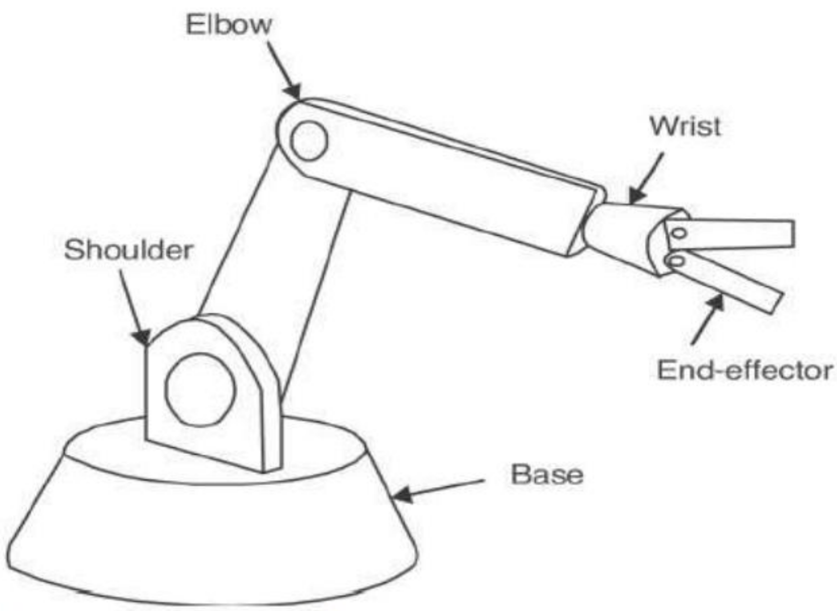
An end effector is an important part of a robotic arm that is attached to the robotic arm's end and serves like a human hand. End effectors are devices attached to the end of a robot's arm to help it interact with the surrounding environment. They are essential to robotic systems as they handle, manipulate, and sense objects.

Types of End Effector:

- Grippers
- Tools

1. Grippers: Grippers are devices, which can be used for holding or gripping an object. These include mechanical hands and anything like hooks, magnets, and suction devices, which can be used for holding or gripping.

2. Tools: Tools are devices, which robots use to perform operations on an object, e.g., drills, paint sprays, grinders, welding torches, and any other tool which get a specific job done.



End Effector Attached to Robot Wrist.

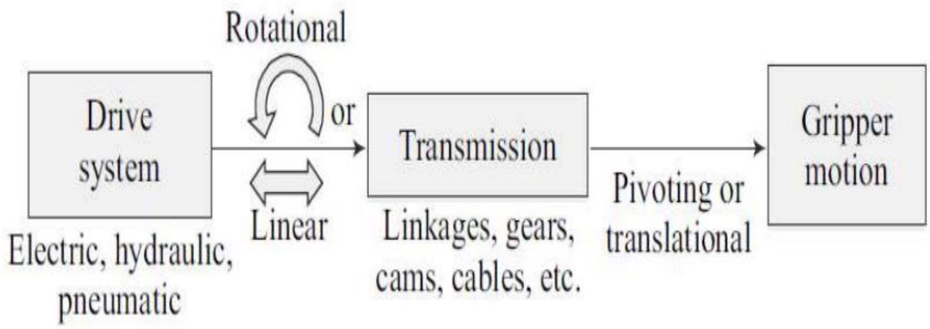
GRIPPERS

Grippers are end-effectors, which are used to grasp an object or a tool, e.g., a grinder, and hold it. Tasks required by the grippers are to hold work pieces and load/unload from/to a machine or conveyer. Grippers can be mechanical in nature using a combination of mechanisms driven by electric, hydraulic, or pneumatic powers. Grippers can be classified based on the principle of grasping mechanism. For example, grippers can hold with the help of suction cups, magnets, or by other means. A gripper is then accordingly referred to as pneumatic gripper, magnetic gripper, etc. Another way to classify a gripper is based on how it holds an object, i.e., based on grasping the object on its exterior (external gripper) or interior (internal gripper) surface.

Types of Grippers

- <u>Mechanical Grippers:</u>
  Mechanical grippers have their jaw movements through pivoting or translational motion using a transmission element, e.g., linkages or gears, etc. The gripper can be of single or double type. While the former has only one gripping device at the robot's wrist, the latter type has two. The double grippers

can be actuated independently and are especially useful in machine loading and unloading. The function of a gripper mechanism is to translate some form of power input, be it electric, hydraulic or pneumatic, into the grasping action of the fingers against the part.



2) Magnetic Grippers

Unlike mechanical grippers, the principle of a magnetic gripper is based on the magnetic property of a gripper. Hence, they can be used only for ferrous objects. They have the following advantages:

- Variations in object sizes can be tolerated.
- Operations are very fast.
- Require only one surface to hold an object. The disadvantages with magnetic grippers are, however, the
- Difficulty to pick thin sheets one at a time because the magnetic force penetrates through more than one sheet. As a result, more than one sheet is picked up. To overcome such disadvantages, one needs to take care during the design stage itself either by limiting the magnetic force by the gripper or by introducing some means (mechanical or otherwise) not to allow more than one sheet to be picked up. Magnetic grippers can have either (i) permanent magnets, or (ii) electromagnets

3) Vacuum Grippers

Such grippers are suitable to handle large flat objects. The material of an object is of no concern with vacuum gripers, except that the object's surface should not have any holes. An example of vacuum gripper which uses suction cups made of elastic materials is shown in Fig. For a vacuum gripper, lifting capacity can be determined from the negative pressure and the effective area of the cups as

$f = pA$

where f is the force or lift capacity, p is the negative pressure, and A is the total effective area of the suction cups

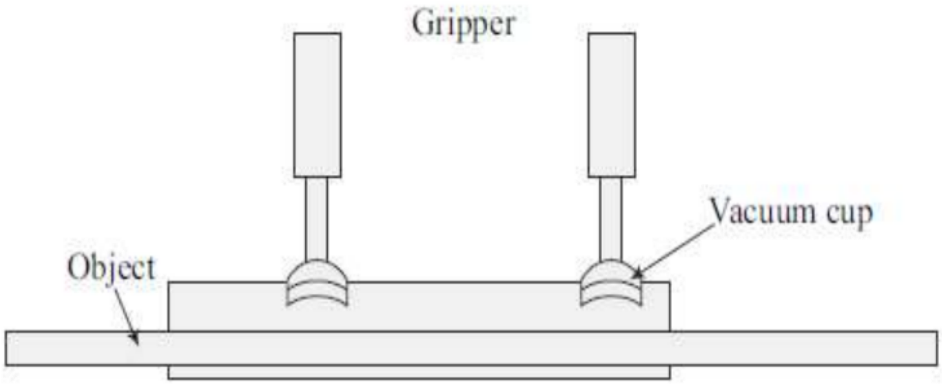


Fig. Vacuum gripper

4) Adhesive Grippers

An adhesive substance used for a grasping action can be used to handle fabrics and other lightweight materials. One of the limitations is that the adhesive substance loses its effectiveness with repeated use. Hence, it has to be continuously fed like a mechanical typewriter's ribbon which needs to be attached to the robot's wrist. Hooks, Scoops, and Others There exist other types of gripping devices, e.g., hooks, scoops or ladles, inflatable devices, etc., based on the need of item to be handled.

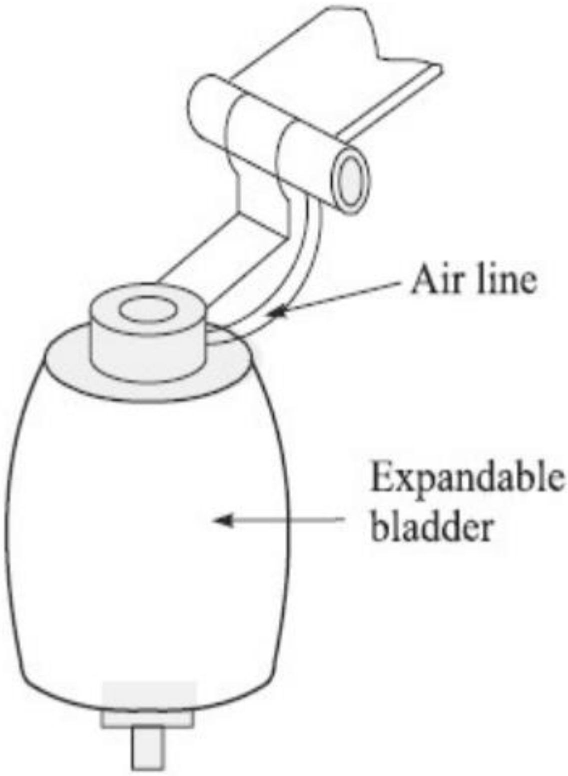


Fig. Expandable bladder to grip objects with holes from inside

Selection of Grippers

Some of the criteria to be used in selecting an appropriate gripper are highlighted below:

- Source of power
- Gripping force
- Gripping style
- Weight
- Environmental capabilities
- Sensor capabilities
- Number of jaws
- Other factors