Course Name : Introduction to Robotics
Course : CSE461
Class Note
Chapter 1 (Introduction to robotics basics)
Class Note [Chapter 1 Part 3]

Subsystem:

In robotics, subsystems are often divided based on the different functions they perform. Three common subsystems in robotics are:

1. **Motion subsystem:** This subsystem is responsible for controlling the motion of the robot. It includes components such as motors, actuators, and sensors that allow the robot to move in a controlled manner. The motion subsystem is often responsible for tasks such as position control, velocity control, and trajectory planning. [ACT]
2. **Recognition subsystem:** This subsystem is responsible for sensing and recognizing the environment around the robot. It includes components such as cameras, lidar, and other sensors that allow the robot to detect objects, people, and other features in the environment. The recognition subsystem is often responsible for tasks such as object detection, tracking, and identification.[SENSE]
3. **Control subsystem:** This subsystem is responsible for controlling the behavior of the robot. It includes components such as processors, controllers, and software that allow the robot to make decisions and carry out actions based on the input from the motion and recognition subsystems. The control subsystem is often responsible for tasks such as path planning, decision making, and coordination. [THINK]

These subsystems are interdependent and work together to enable the robot to perform its intended function. For example, the recognition subsystem might detect an object, and the control subsystem might use that information to plan a path for the robot to move around the object, while the motion subsystem controls the robot's movements to follow that path. By dividing the robot into these subsystems, engineers can design and optimize each subsystem independently, which can lead to more efficient and effective robotic systems.

Manipulator :

In robotics, a manipulator is a robotic arm that is designed to move objects or perform tasks in a specific environment. The manipulator is typically made up of a series of rigid links that are connected by joints or axes, allowing the arm to move in different directions and perform a variety of tasks. The end of the manipulator often includes an end effector, which is a tool or device that is used to interact with the environment.

Manipulators are used in a wide range of applications, from manufacturing and assembly to construction and surgery. They are often used in situations where it is difficult or dangerous for humans to perform tasks, or where precision and accuracy are critical. For example, in manufacturing, manipulators can be used to move heavy objects or perform repetitive tasks that would be difficult for humans to do for extended periods of time.

End Effector

In robotics, an end effector is a tool or device that is attached to the end of a robotic manipulator, such as a robotic arm. The end effector is designed to interact with the environment in order to perform a specific task, such as grasping an object, cutting a material, or welding two pieces together.

The end effector is typically designed to meet the specific requirements of the task at hand, and can vary widely in terms of size, shape, and functionality. For example, a robotic arm used for welding might have an end effector that includes a welding torch and a wire feeder, while a robotic arm used for assembly might have an end effector that includes grippers or suction cups to hold and manipulate parts.

End effectors are often designed to be interchangeable, so that the same manipulator can be used for multiple tasks by simply swapping out the end effector. This allows for greater flexibility and efficiency in robotic systems, as the same robotic arm can be used for a variety of tasks without needing to be reconfigured or replaced.

Actuators :

In robotics, an actuator is a component that is used to convert energy into motion or force. The actuator is responsible for moving the robotic system or its components, such as the manipulator or end effector, in a controlled manner. There are several different types of actuators that are commonly used in robotics, each with its own strengths and limitations.

Electric Actuators: Electric actuators are the most common type of actuators used in robotics. They convert electrical energy into motion or force, and can be controlled precisely using software or other control systems. Some examples of electric actuators include DC motors, stepper motors, and servo motors. Electric actuators are typically lightweight, compact, and easy to control, making them a popular choice for a wide range of applications. However, they may not be as powerful or able to generate as much force as hydraulic or pneumatic actuators.

Hydraulic Actuators: Hydraulic actuators use pressurized fluid, typically oil or water, to generate force and motion. They are often used in applications that require high levels of force or power, such as heavy-duty construction or industrial equipment. Hydraulic actuators can generate a lot of force and are able to maintain a constant force over long periods of time. However, they may be more complex and expensive to maintain than electric or pneumatic actuators, and may require a separate hydraulic system to operate.

Pneumatic Actuators: Pneumatic actuators use compressed air or other gasses to generate motion and force. They are often used in applications that require quick movements or high levels of precision, such as in assembly lines or robotics research. Pneumatic actuators are typically lightweight, easy to control, and able to generate a lot of force quickly. However, they may not be as precise or able to maintain a constant force as hydraulic or electric actuators, and may require a separate air compressor or other equipment to operate.

Motors:

DC Motor:

Advantages:

- Simple and easy to use.
- Provides high starting torque.
- Allows for speed control.
- Low cost compared to other types of motors.
- Can operate over a wide range of temperatures and environments.

Limitations:

- Cannot maintain a constant speed under varying loads.
- May experience reduced efficiency at low speeds.
- Requires regular maintenance to ensure proper operation.

Uses:

- DC motors are useful when you need a simple, low-cost motor that can provide high starting torque and speed control.
- They are commonly used in applications such as electric vehicles, industrial machinery, and robotics.

Servo Motor:

Advantages:

- Provides accurate and precise control over position, velocity, and acceleration.
- Can maintain a constant speed under varying loads.
- Provides high torque output.
- Can operate at high speeds.
- Low electrical noise output.

Limitations:

- More expensive than DC or stepper motors.
- May require more complex control circuitry.
- Can be sensitive to vibration and shock.
- Limited angle of rotation.
- Requires precise calibration to achieve optimal performance.

Uses:

- Servo motors are useful when you need accurate and precise control over the position, velocity, and acceleration of the motor.
- They are commonly used in applications such as robotics, industrial automation, and aerospace systems.
- Servo motors are also useful in applications where high-speed operation and high torque are required, such as in the control of drones, robotics, and electric vehicles.

Stepper Motor:

Advantages:

- Provides precise control over positioning and speed.
- Can maintain a constant speed under varying loads.
- Low cost compared to servo motors.
- Provides high torque output at low speeds.
- Easy to use and control.

Limitations:

- Less efficient than DC motors at high speeds.
- Can experience resonance issues at certain speeds.
- Limited speed range.
- Limited angle of rotation.
- Can experience increased electrical noise output.

Uses:

- Stepper motors are useful when you need precise positioning control, such as in CNC machines, 3D printers, and robotics.
- They can also be used in applications where low-speed torque is required, such as in surveillance cameras or robotics.

Transmission systems:

Transmission systems are essential components of robots and other machinery that convert rotational motion into linear or angular motion to achieve the desired output. Four common types of transmission systems used in robotics are belt transmission, chain transmission, gear transmission, and link mechanism transmission.

Belt Transmission: Belt transmission systems use flexible belts made of rubber or other materials to transfer rotational motion from one pulley to another. They are commonly used in applications where speed reduction or torque multiplication is required, such as in conveyors, printing presses, and agricultural equipment. Belt transmission systems are simple, cost-effective, and easy to maintain, but they may slip under heavy loads or high speeds.

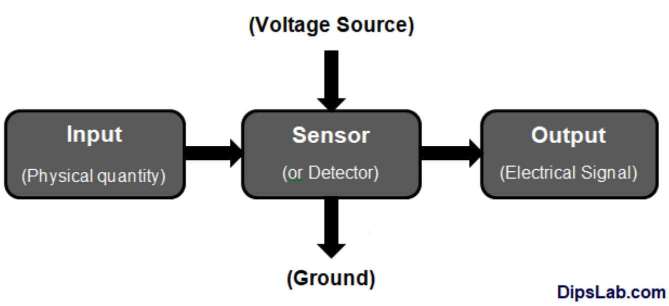
Chain Transmission: Chain transmission systems use roller chains to transfer power between two or more sprockets. They are commonly used in high-power, high-torque applications, such as in motorcycles, bicycles, and heavy machinery. Chain transmission systems are durable, long-lasting, and able to handle high loads and speeds. However, they may require regular lubrication and maintenance to prevent wear and tear.

Gear Transmission: Gear transmission systems use meshing gears to transmit rotational motion and power between two or more shafts. They are commonly used in applications that require precise speed and torque control, such as in automobiles, airplanes, and machine tools. Gear transmission systems are highly efficient, compact, and able to transmit large amounts of power. However, they may be noisy and require regular maintenance to ensure proper lubrication and alignment.

In summary, the choice of transmission system will depend on the specific requirements of the application, including factors such as speed, torque, precision, and environmental conditions. Each type of transmission system has its own strengths and limitations, and it is important to choose the right type of transmission system for the application in order to achieve optimal performance and efficiency.

Sensor :

A sensor is a device or subsystem that detects and responds to a physical stimulus, such as light, temperature, pressure, or motion, and converts it into an electrical or mechanical signal that can be processed, analyzed, or used to control other devices or systems. Sensors are essential components of many electronic, mechanical, and robotic systems, and are used in a wide range of applications, such as automotive, aerospace, medical, environmental monitoring, and consumer electronics. They can be classified based on the physical phenomenon they detect, the type of output they provide, and their operating principles. Some common types of sensors include temperature sensors, pressure sensors, proximity sensors, optical sensors, and motion sensors.



Types of sensors:

Active and passive sensors are two different types of sensors used in various applications.

1. **Active sensors:** Active sensors emit energy or radiation to measure the properties of an object or environment. They require a power source to operate and can be used to gather data in situations where passive sensors are unable to function. Some examples of active sensors include radar, lidar, and ultrasonic sensors.

Radar sensors emit radio waves that are reflected back by objects in their path. By measuring the time it takes for the waves to return and the intensity of the reflection, radar sensors can determine the location, distance, and speed of objects.

Lidar sensors use laser beams to scan an area and create a 3D map of the environment. They measure the time it takes for the laser beams to reflect off of objects and return to the sensor, allowing them to create highly detailed and accurate maps.

Ultrasonic sensors emit high-frequency sound waves that bounce off objects and return to the sensor. By measuring the time it takes for the waves to return, ultrasonic sensors can determine the distance and location of objects.

2. **Passive sensors:** Passive sensors detect and measure the energy emitted by objects in the environment without emitting any energy themselves. They do not require a power source to operate and are often used in situations where active sensors may interfere with the environment or other sensors. Some examples of passive sensors include infrared sensors and optical sensors.

Infrared sensors detect the heat energy emitted by objects and convert it into an electrical signal that can be processed or displayed. They are commonly used in temperature measurement, motion detection, and other applications.

Optical sensors use light to detect and measure various physical properties, such as color, intensity, and wavelength. They can be used in applications such as image sensing, position sensing, and spectroscopy.

Laser Scanner:

Laser scanners work by emitting a laser beam and measuring the time it takes for the beam to bounce back to the scanner after reflecting off an object. By measuring the round-trip time of the laser beam, the scanner can calculate the distance to the object. The laser beam is usually swept over the field of view of the scanner using a rotating mirror or prism, which allows the scanner to create a 3D map of the environment.

LIDAR:

LIDAR (Light Detection and Ranging) is a remote sensing technology that uses laser light to measure the distance to objects in its field of view. LIDAR technology has many applications, including autonomous vehicles, surveying, mapping, and atmospheric monitoring.

LIDAR systems typically consist of a laser scanner, a receiver, and a data processing unit. The laser scanner emits laser pulses that travel through the atmosphere and bounce off objects in their path. The receiver detects the reflected laser pulses and measures their time of flight and intensity. The data processing unit then uses this information to create a 3D map of the environment.

There are two main categories of LIDAR systems, including:

1. **Airborne LIDAR:** These LIDAR systems are mounted on aircraft and are used for mapping large areas, such as forests, coastlines, and urban areas. Airborne LIDAR systems can cover large areas quickly and provide high-resolution maps.

2. **Terrestrial LIDAR:** These LIDAR systems are used for mapping smaller areas, such as building interiors, archaeological sites, and construction sites. Terrestrial LIDAR systems are mounted on tripods and can provide high-resolution 3D maps.

LIDAR technology has revolutionized many industries by providing accurate and detailed 3D maps of the environment. It has become an essential tool for autonomous vehicles, robotics, and remote sensing applications. However, LIDAR systems can be expensive and require skilled operators to operate and maintain.

EEG:

An EEG (electroencephalogram) headset is a device that is worn on the head to record electrical activity from the brain. It typically consists of multiple electrodes that are placed on the scalp and connected to a recording device. EEG headsets are used to measure brain activity and are often used in medical settings to diagnose neurological conditions such as epilepsy.

LEAP Motion Sensor:

LEAP Motion is a hand-tracking sensor that allows users to control a computer or other digital device using natural hand and finger movements. The LEAP Motion sensor uses infrared cameras and LED lights to track the movement of the user's hands and fingers in three-dimensional space. It is a small, desktop-sized device that can be placed on a desk or other surface in front of a computer.

The LEAP Motion sensor can track the movement of both hands and all ten fingers with high precision and low latency. This allows users to control digital content with natural gestures such as swiping, tapping, pinching, and grabbing. The sensor is compatible with a variety of software and applications, including games, art and design tools, and virtual reality experiences.

The LEAP Motion sensor can be used as a standalone device, or it can be integrated into other hardware such as VR headsets or smart glasses. The sensor is also compatible with a range of programming languages and platforms, making it a versatile tool for developers and creators.

Overall, the LEAP Motion sensor is a cutting-edge technology that allows users to interact with digital content in a more natural and intuitive way. Its precise tracking and low latency make it a powerful tool for gaming, design, and other applications where precise hand and finger movements are important.

MYO Sensor:

A MYO sensor is a type of wearable technology that uses electromyography (EMG) to measure muscle activity. The sensor consists of several small electrodes that detect the electrical signals produced by muscles when they contract.

To use a MYO sensor, you would typically attach it to your skin over the muscle you want to measure. When you contract that muscle, the sensor will detect the electrical signals and translate them into a digital signal that can be used to control a device, such as a computer or a prosthetic limb.