Course Name : Introduction to Robotics
Course : CSE461
Class Note
Chapter 1 (Introduction to robotics basics)

Control Software:

Robot Vision:
Robot Vision is a part of control software that allows a manipulator robot to observe and understand its surroundings using visual sensors like cameras. To identify and find items in the environment of the robot, this comprises image processing, object recognition, and tracking. The robot's vision system is essential to its ability to carry out tasks like grasping and manipulating items, navigation, and inspection that call for visual perception.

PID Control:
Robot manipulator control frequently employs PID control, a form of feedback control. PID, the initials for the three elements that make up the control algorithm, stands for proportional, integral, and derivative. PID control uses the proportional, integral, and derivative terms to fine-tune the control signal, adjusting the robot's output based on the discrepancy between the desired output and the actual output. PID control, which is frequently used in robot manipulator control, is effective in controlling the robot's position and velocity.

Trajectory/Motion Planning:
Trajectory/Motion Planning is a part of control software that determines the best path for a robot manipulator to take while balancing restrictions such end-effector orientation, joint limits, and obstructions. The robot must follow a set of joint positions generated by this component in order to complete the intended task. Trajectory/Motion planning, which is frequently utilized in applications like pick-and-place, assembly, and welding, is crucial for enabling a robot manipulator to carry out tasks reliably and effectively.

Localization:
Control software's localization function establishes the position and orientation of a robot manipulator in a specific environment. The robot needs localization to accurately carry out duties and interact with its surroundings. In applications like navigation and manipulation, this component frequently makes use of sensors like cameras, lasers, and inertial sensors to assess the robot's position and orientation.

Manipulator Control:
A part of the control software that manages a robot manipulator's movement is called manipulator control. To produce the control signals that move the robot's joints, this component uses data from

sensors as well as input from other components like trajectory/motion planning and PID control. The robot's ability to do a variety of jobs depends on the accuracy and safety of the manipulator control, which is in charge of making sure the robot moves.

UAV Navigation:
UAV (Unmanned Aerial Vehicle) Navigation is a component of control software that allows UAVs to travel autonomously through their environment. This component estimates the UAV's position and orientation using sensors like GPS, cameras, and lasers, and it creates the control signals required to follow the planned trajectory. To conduct activities like delivery, inspection, and surveillance, UAV navigation is essential.

Sensors Calibration and Sensor Fusion:
Sensors Calibration and Sensor Fusion are components of control software that ensure the accuracy and reliability of sensor data. Sensors Calibration involves adjusting the sensor parameters to reduce errors and ensure that the sensor readings are consistent with the actual values. Sensor Fusion involves combining the data from multiple sensors to improve the accuracy and reliability of the measurements. Sensors Calibration and Sensor Fusion are critical for enabling accurate and reliable robot control and are commonly used in applications such as localization and navigation.

Kinematics and Dynamics:
Kinematics and Dynamics are components of control software that describe the motion of a robot manipulator. Kinematics describes the relationship between the robot's joint positions and the position and orientation of the end-effector. Dynamics describes the forces and torques that act on the robot and how they affect its motion. Kinematics and Dynamics are essential for enabling accurate control of robot manipulators and are commonly used in applications such as trajectory/motion planning and manipulation.

Interfacing:
A feature of control software called interface permits communication between the controller, sensors, actuators, and other parts of the robot system. In order for the various components to communicate and share data, software and hardware interfaces must be designed and put into place. For the various components to operate harmoniously and complete the intended tasks, interface is essential.

Communication:
The control software's communication module enables the robot system to communicate with other robots, computers, and sensors, among other external systems and devices. Implementing interfaces and protocols that permit data interchange between the robot system and external devices is required for this. For the robot system to interface with other systems and carry out more difficult tasks, communication is essential. Also, it allows for remote monitoring and control of the robot system, which is advantageous for teleoperation and remote maintenance applications.

Control Hardware:

Control hardware in robotics refers to the controller that continuously reads from sensors like motor encoders, force sensors, or even vision or depth sensors, and updates the robot's movements accordingly.

Microcontroller: Microcontrollers can interact with the physical world through sensors and actuators. Sensors are devices that detect and respond to changes in the environment, such as temperature, light, or motion. The microcontroller can read data from sensors and use it to make decisions or trigger actions. Actuators, on the other hand, are devices that can move or control a mechanism or system. The microcontroller can send signals to actuators to control their behavior.

For example, in a temperature control system, a temperature sensor might detect the current temperature and send that information to the microcontroller. The microcontroller can then compare the current temperature to a desired setpoint and send a signal to an actuator, such as a heater or fan, to adjust the temperature accordingly.

Arduino : Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs from various sources such as sensors or buttons and turn them into outputs such as activating a motor or turning on an LED.

Autonomous Docking:

Autonomous docking is another crucial feature for spacecraft, especially those used for satellite deployment and space exploration. Autonomous docking in space demands a high degree of accuracy and dependability because even minor mistakes or issues can have negative effects.

Autonomous docking in space often uses sensors like cameras and lidar to find the target docking port's precise location in relation to the spaceship. The next step is for the spacecraft to create a 3D map of its surroundings using mapping algorithms in order to devise a direct and safe route to the docking port. Additionally, the spacecraft must employ control algorithms to modify its motion and orientation in response to data from its sensors in order to properly align with the docking mechanism.

Mars Rover:

The Mars Rover is a robotic vehicle that is designed to explore the surface of Mars. It is equipped with a wide range of features that allow it to navigate the harsh Martian environment, collect data and images, and conduct scientific experiments. Here are some of the key features of the Mars Rover:

1. Robust wheels: The Mars Rover has six wheels, each with its own motor, that are designed to withstand the rough terrain of Mars. The wheels are also equipped with treads to provide better traction on sandy and rocky surfaces.

2. Cameras: It has a variety of cameras that allow it to take high-resolution images and videos of the Martian surface. These cameras include a mast camera that can take panoramic images and a close-up camera that can capture detailed images of rocks and other features.

3. Arm and tools: A robotic arm that can extend up to 2 meters and is equipped with a range of tools, including a drill, a scoop, and a brush. These tools allow the rover to collect samples of rocks and soil, which can be analyzed by onboard scientific instruments.

4. Scientific instruments: The Mars Rover is equipped with a range of scientific instruments that allow it to analyze the composition of rocks and soil on Mars. These instruments include a spectrometer, which can identify minerals and organic compounds, and a laser that can vaporize rocks and analyze their composition.

5. Communication system: The Mars Rover is equipped with a sophisticated communication system that allows it to send and receive data from Earth. The rover uses a high-gain antenna to communicate with orbiters around Mars, which then relay the data to Earth.

6. Power system: The Mars Rover is powered by a set of solar panels that convert sunlight into electricity. The rover also has a rechargeable battery that allows it to operate during periods of low sunlight, such as during dust storms.

Roomba:

Robotic vacuum cleaners under the Roomba brand are made by the firm iRobot. These robots use a variety of sensors and programming to navigate around obstacles and prevent falling down steps as they clean floors autonomously in homes and other indoor spaces.

Typically rounded, roombas come in a variety of sizes and features, based on the particular model. They can be set to clean automatically on a schedule or manually controlled using a mobile app. They use brushes and suction to pick up dirt and debris. Some Roomba models also have mapping features, enabling them to more effectively travel by drawing a map of the area they are cleaning.