Artificial Intelligence & Robotics

Assignment 5

Unit 5: Robotics

1. *Explain robotics and different types of robots. Also, state applications of robotics in Artificial Intelligence.*

Robotics is a branch of AI, which is composed of Electrical Engineering, Mechanical Engineering, and Computer Science for designing, construction, and application of robots.

Aspects of Robotics
- The robots have mechanical construction, form, or shape designed to accomplish a particular task.
- They have electrical components which power and control the machinery.
- They contain some level of computer program that determines what, when and how a robot does something.

Different types of Robots

Pre-Programmed Robots
Pre-programmed robots operate in a controlled environment where they do simple, monotonous tasks. The arm serves one function — to weld a door on, to insert a certain part into the engine, etc. — and its job is to perform that task longer, faster and more efficiently than a human.

Humanoid Robots
Humanoid robots are robots that look like and/or mimic human behaviour. These robots usually perform human-like activities (like running, jumping and carrying objects), and are sometimes designed to look like us, even having human faces and expressions.

Autonomous Robots
Autonomous robots operate independently of human operators. These robots are

usually designed to carry out tasks in open environments that do not require human supervision.

Teleoperated Robots
Teleoperated robots are mechanical bots controlled by humans. These robots usually work in extreme geographical conditions, weather, circumstances, etc.

Augmenting Robots
Augmenting robots either enhance current human capabilities or replace the capabilities a human may have lost.

Applications of Robotics

The robotics has been instrumental in the various domains such as −

Industries − Robots are used for handling material, cutting, welding, color coating, drilling, polishing, etc.

Military − Autonomous robots can reach inaccessible and hazardous zones during war. Mostly it's main function is to destroy life-threatening objects safely.

Medicine − The robots are capable of carrying out hundreds of clinical tests simultaneously, rehabilitating permanently disabled people, and performing complex surgeries such as brain tumours.

Exploration − The robot rock climbers used for space exploration; underwater drones used for ocean exploration are to name a few.

Entertainment − Disney's engineers have created hundreds of robots for movie making.

2. *Explain the mechanism of robotic locomotion. Also enlist and explain types of locomotion.*

Locomotion is the mechanism that makes a robot capable of moving in its environment. There are various types of locomotion −

- Legged
- Wheeled
- Combination of Legged and Wheeled Locomotion
- Tracked slip/skid

Legged Locomotion

- This type of locomotion consumes more power while demonstrating walk, jump, trot, hop, climb up or down, etc.

- It requires more number of motors to accomplish a movement. It is suited for rough as well as smooth terrain where irregular or too smooth surface makes it consume more power for a wheeled locomotion. It is little difficult to implement because of stability issues.

- It comes with the variety of one, two, four, and six legs. If a robot has multiple legs then leg coordination is necessary for locomotion.

The total number of possible **gaits** (a periodic sequence of lift and release events for each of the total legs) a robot can travel depends upon the number of its legs.

If a robot has k legs, then the number of possible events $N = (2k-1)!$.

Wheeled Locomotion

It requires fewer number of motors to accomplish a movement. It is little easy to implement as there are less stability issues in case of more number of wheels. It is power efficient as compared to legged locomotion.

- **Standard wheel** − Rotates around the wheel axle and around the contact

- **Castor wheel** − Rotates around the wheel axle and the offset steering joint.

- **Swedish 45° and Swedish 90° wheels** − Omni-wheel, rotates around the contact point, around the wheel axle, and around the rollers.

- **Ball or spherical wheel** − Omnidirectional wheel, technically difficult to implement.

Slip/Skid Locomotion

In this type, the vehicles use tracks as in a tank. The robot is steered by moving the tracks with different speeds in the same or opposite direction. It offers stability because of large contact area of track and ground.

3. Explain path planning and localization in point robot.

Path-planning is an important primitive for autonomous mobile robots that lets robots find the shortest – or otherwise optimal – path between two points. Otherwise optimal paths could be paths that minimize the amount of turning, the amount of braking or whatever a specific application requires. Algorithms to find a shortest path are important not only in robotics, but also in network routing, video games and gene sequencing.

Path-planning requires a map of the environment and the robot to be aware of its location with respect to the map.

Robot localization is the process of determining where a mobile robot is located with respect to its environment. Localization is one of the most fundamental competencies required by an autonomous robot as the knowledge of the robot's own location is an essential precursor to making decisions about future actions.

In a typical robot localization scenario, a map of the environment is available and the robot is equipped with sensors that observe the environment as well as monitor its own motion.

The localization problem then becomes one of estimating the robot position and orientation within the map using information gathered from these sensors. Robot localization techniques need to be able to deal with noisy observations and generate not only an estimate of the robot location but also a measure of the uncertainty of the location estimate.

4. Explain Robotic Mapping

Robotic mapping is that of acquiring a spatial model of a robot's environment which is commonly used for robot navigation (e.g. localization).

To acquire a map, robots must possess sensors that enable it to perceive the outside world. Sensors commonly brought to bear for this task include cameras, range finders using sonar, laser, and infrared technology, radar, tactile sensors, compasses, and GPS.

As a robot navigates its environment, it must compose a data model or "map" of its surroundings, using data from available sensors. This map is the robotic equivalent of what we might call a picture in our mind's eye. But whereas our human "map" draws on sensory information, a robot relies on data fused from depth cameras/ LIDAR/ sensors using the SLAM algorithm.

5. Explain different types of sensors used in robots.

Light Sensors

Light sensors are used to identify changes in light or voltage. The two primary light sensors are photoresistor and photovoltaic. A photoresistor is a kind of resistor that changes with light intensity. That means the more light that's shined the fewer resistance. This sensor is relativity inexpensive and can be used in most robots.

Sound Sensors

This sensor (usually a microphone) identifies sound and, in return, sends a voltage that's equal to the sound level. If designed properly, a basic robot can navigate from the sound it receives. While more complex robots can use the microphone for voice recognition and speech.

Proximity Sensor

Proximity sensors can identify the presence of a nearby object without any physical contact. These sensors work by transmitting electromagnetic radiation and examining the signal for any interferences. While there are a variety of proximity sensors; these are the three most common types used in robotics:

- Infrared Transceivers
- Ultrasonic Sensor
- Phototresister

Infrared transceivers are typically the best proximity sensors due to its long-last ability and its affordability. However, infrared transceivers may malfunction in conditions like snow, fog, and harsh sunlight.

Position Sensor

Position sensors locate the position of a robot from an indoor location or an outdoor position. Linear position sensors are one of the best types of position sensors. Since they're inexpensive and provide excellent accuracy.

Contact Sensor

Contact sensors are those which require physical contact against other objects to trigger. A push button switch, limit switch or tactile bumper switch are all examples of contact sensors. These sensors are mostly used for obstacle avoidance robots. When these switches hit an obstacle, it triggers the robot to do a task, which can be reversing, turning, switching on a LED, Stopping etc.

Distance Sensor

Most proximity sensors can also be used as distance sensors, or commonly known as Range Sensors; IR transceivers and Ultrasonic Sensors are best suited for distance measurement.

Pressure Sensors

As the name suggests, pressure sensor measures pressure. Tactile pressure sensors are useful in robotics as they are sensitive to touch, force and pressure. If you design a robot hand and need to measure the amount of grip and pressure required to hold an object, then this is what you would want to use.

Tilt Sensors

Tilt sensors measure tilt of an object. In a typical analog tilt sensor, a small amount of mercury is suspended in a glass bulb. When mercury flows towards one end, it closes a switch which suggests a tilt.

Acceleration Sensor

An accelerometer is a device which measures acceleration and tilt. There are two kinds of forces which can affect an accelerometer: Static force and Dynamic Force

Static Force
Static force is the frictional force between any two objects. For example earth's gravitational force is static which pulls an object towards it. Measuring this gravitational force can tell you how much your robot is tilting. This measurement is exceptionally useful in a balancing robot, or to tell you if your robot is driving uphill or on a flat surface.

Dynamic force
Dynamic force is the amount of acceleration required to move an object. Measuring this dynamic force using an accelerometer tells you the velocity/speed at which your robot is moving. We can also measure vibration of a robot using an accelerometer, if in any case you need to.

Gyroscope

A gyroscope or simply Gyro is a device which measures and helps maintain orientation using the principle of angular momentum.

IMU

Inertial Measurement Units combine properties of two or more sensors such as Accelerometer, Gyro, Magnetometer, etc, to measure orientation, velocity and gravitational forces.

Voltage Sensors

Voltage sensors typically convert lower voltages to higher voltages, or vice versa.

Current Sensors

Current sensors are electronic circuits which monitor the current flow in a circuit and output either a proportional voltage or a current. Most current sensors output an analog voltage between 0V to 5V which can be processed further using a microcontroller.