## **UNIT V:** INTRODUCTION TO ROBOTICS AND SENSING TECHNIQUES

* **1. Introduction to Robotics**

**1.1 Social Implications of Robotics**

* **Impact on Employment**: Robotics can automate repetitive tasks, potentially displacing certain jobs while creating new ones in technology and maintenance.
* **Ethical Considerations**: Issues related to privacy, security, and the ethical treatment of robots and AI systems.
* **Quality of Life**: Robots can improve quality of life through assistive technologies, healthcare robots, and increased safety.

**1.2 Brief History of Robotics**

* **Early Concepts**: Ancient automata and mechanical devices from ancient Greece, China, and the Middle Ages.
* **Industrial Revolution**: Introduction of early industrial robots in the 20th century for manufacturing processes.
* **Modern Era**: Advances in AI, machine learning, and computer vision leading to sophisticated robots used in various fields like healthcare, exploration, and service industries.

**1.3 Hierarchical Paradigm**

* **Overview**: A control architecture where tasks are organized in a hierarchy from high-level decision-making to low-level motor control.
* **Components**:
  + **High-Level Control**: Decision-making, planning, and strategy formulation.
  + **Mid-Level Control**: Task decomposition and coordination of actions.
  + **Low-Level Control**: Direct control of actuators and sensors.
* **Advantages**: Clear structure, modularity, and ease of debugging.

**1.4 Attributes of Reactive Paradigm**

* **Definition**: A control approach where robots respond to stimuli or environmental changes in real-time without pre-planned actions.
* **Characteristics**:
  + **Simplicity**: Direct response to sensor inputs.
  + **Robustness**: Ability to handle dynamic environments and unexpected changes.
  + **Latency**: Reduced latency in decision-making as actions are immediate.

**1.5 Subsumption Architecture**

* **Concept**: A layered control architecture where each layer represents a different behavior or response.
* **Layers**:
  + **Basic Behaviors**: Primitive actions such as obstacle avoidance.
  + **Higher-Level Behaviors**: Complex behaviors like navigation or task execution.
* **Principle**: Higher-level layers can override lower-level behaviors but cannot directly control them.
* **Advantages**: Flexibility, robustness, and adaptability to complex environments.

**1.6 Potential Fields and Perception**

* **Potential Fields**: A method for robot navigation where the environment generates attractive or repulsive forces to guide the robot.
  + **Attractive Fields**: Draw the robot towards a goal.
  + **Repulsive Fields**: Push the robot away from obstacles.
* **Perception**: The process of acquiring and interpreting sensory information to make decisions or understand the environment.
  + **Role**: Essential for dynamic navigation and interaction with the environment.
* **2. Common Sensing Techniques for Reactive Robots**

**2.1 Logical Sensors**

* **Definition**: Sensors that provide binary or discrete data, indicating the presence or absence of a condition.
* **Examples**:
  + **Contact Sensors**: Detect physical contact or collisions.
  + **Limit Switches**: Indicate when a robot component reaches a predefined position.

**2.2 Behavioral Sensor Fusion**

* **Definition**: Combining data from multiple sensors to form a coherent understanding of the environment.
* **Techniques**:
  + **Weighted Fusion**: Assigning weights to sensor inputs based on their reliability.
  + **Complementary Fusion**: Using different sensors to complement each other's weaknesses (e.g., combining visual and depth information).

**2.3 Proprioceptive Sensors**

* **Definition**: Sensors that provide information about the internal state of the robot, such as its position or motion.
* **Examples**:
  + **Encoders**: Measure rotational angles of motors or wheels.
  + **Gyroscopes**: Measure angular velocity or orientation.
  + **Accelerometers**: Measure acceleration forces acting on the robot.

**2.4 Proximity Sensors**

* **Definition**: Sensors that detect the presence of objects within a certain range without physical contact.
* **Types**:
  + **Infrared Sensors**: Measure distance using infrared light reflection.
  + **Ultrasonic Sensors**: Measure distance using sound waves.
  + **Capacitive Sensors**: Detect changes in capacitance caused by the presence of an object.

**2.5 Topological Planning**

* **Definition**: Path planning method that focuses on the connectivity and arrangement of environment features rather than precise distances.
* **Approach**:
  + **Graph-Based**: Representing the environment as a graph of nodes and edges.
  + **Traversal**: Finding paths through the graph based on connectivity rather than exact measurements.

**2.6 Metric Path Planning**

* **Definition**: Path planning method that involves calculating precise distances and trajectories in the environment.
* **Techniques**:
  + **Grid-Based Planning**: Dividing the environment into a grid and planning paths based on grid cells.
  + **Sampling-Based Planning**: Using random samples to build a path through the environment (e.g., RRT - Rapidly-exploring Random Trees).
  + **Graph-Based Algorithms**: Algorithms like A\* and Dijkstra’s for finding optimal paths based on distance metrics.