Chapter 3: Sensors and Actuators

📘 Description

Sensors and actuators are the foundation of IoT. This chapter introduces the various types of sensors used to collect data from the physical world and actuators that enable devices to perform actions in response to that data.

🎯 Learning Objectives

By the end of this chapter, you will be able to:

- Understand the role of sensors and actuators in IoT systems.
- Identify common types of sensors and their applications.
- Understand how actuators convert signals into physical actions.
- Learn how to interface sensors and actuators with microcontrollers.

🔍 Section 1: What are Sensors?

Sensors are devices that detect and measure physical properties like temperature, humidity, light, motion, or gas levels and convert them into digital or analog signals.

🔑 Common Sensor Types:

Sensor Type	Measured Parameter	Example Use Case
Temperature sensor	Heat/temperature	Smart thermostats, weather stations
Humidity sensor	Air moisture	Greenhouse monitoring

Light sensor (LDR)	Light intensity	Automatic lighting systems
Motion sensor (PIR)	Movement detection	Security systems
Gas sensor (MQ-series)	Gas concentrations (e.g., CO)	Air quality monitoring
Ultrasonic sensor	Distance	Obstacle detection in robots

⚙️ Section 2: What are Actuators?

Actuators are devices that convert electrical signals into physical action, such as rotation, movement, or sound. They are used to perform tasks based on decisions made by the system.

🔑 Common Actuator Types:

Actuator Type	Function	Example Use Case
Servo motor	Precise angular movement	Robotic arms, camera positioning
DC motor	Continuous rotation	Fans, wheels of smart cars
Relay	Switching high-power devices	Smart home automation
Buzzer	Emits sound signal	Alarm systems
Solenoid valve	Controls fluid/gas flow	Smart irrigation systems

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🔗 Section 3: Sensor and Actuator Interfacing

- **Digital Pins**: Used for on/off sensors like motion detectors or relays
- **Analog Pins**: Required for variable signals like temperature or light sensors
- **PWM (Pulse Width Modulation)**: Used for actuators like servo motors

🧪 Example (Arduino Code to read temperature sensor):

cpp
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```
int tempPin = A0;
```

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int tempValue = analogRead(tempPin);
  float voltage = tempValue * 5.0 / 1023.0;
  float temperature = (voltage - 0.5) * 100;
  Serial.println(temperature);
  delay(1000);
}
```

🧠 Section 4: Real-Life Integration

- **Smart AC**: Temperature sensor + relay to control compressor
- **Automatic streetlight**: LDR sensor + relay to switch lights
- **Obstacle-avoiding robot**: Ultrasonic sensor + DC motors

✅ Chapter Summary

- Sensors collect data from the environment; actuators act on that data.
- Common sensors include temperature, motion, and light sensors.
- Common actuators include motors, relays, and buzzers.
- Microcontrollers interact with sensors/actuators using digital, analog, and PWM signals.