CSE435 – Robotics

Lecture 2 Notes

What Makes a Machine a Robot

A robot integrates three main functions:

- **Sensing** – perceiving information about its environment.
- **Planning** – deciding what actions to take.
- **Acting** – interacting physically with the environment.

Why Robots Need Sensors

Robots need sensors to:

- Determine **where they are** (localization).
- Avoid **obstacles**.
- Perform **task-specific sensing**, e.g.:
    - Detecting crop lines (for agricultural robots).
    - Detecting and tracking faces (for humanoid robots).

Sensors vs. Detectors

- **Sensor:** Converts a physical quantity (like pressure, light, or temperature) into an electrical signal readable by a controller.
- **Detector:** Includes a sensor and a **decision circuit** that reacts when a threshold is reached (e.g., smoke detector triggers an alarm).

Sensor Selection Factors

Important criteria for choosing a sensor:

- Measurement technique
- Size & weight
- Operating temperature
- Power consumption
- Price range

Sensor Data Transfer

Two main methods:

1. **CPU-Initiated (Polling):** CPU continuously checks sensor status.
2. **Sensor-Initiated (Interrupt):** Sensor notifies CPU when data is ready (more efficient).

Sensor Categories

From an **engineering perspective:** classified by **output type** (analog/digital, binary). From a **robotic perspective:** classified by **function and location**:

- **Local (on-board)** vs. **Global (external)**
- **Internal (robot's state)** vs. **External (environment)**
- **Passive** (don't affect environment, e.g. camera, gyroscope) vs. **Active** (emit signals, e.g. sonar, infrared)

Binary Sensors

Simplest sensors that output **0 or 1**, e.g. touch/tactile sensors.

Analog vs. Digital Sensors

- **Analog Sensors:** Output continuous voltage; require **A/D converter**. Examples: microphone, analog IR sensor, barometer.
- **Digital Sensors:** Output digital data via parallel or serial interfaces (RS232, SPI, etc.); usually more accurate.

Example: TC72 Temperature Sensor

- Uses **synchronous serial digital interface**.
- Data transferred bit-by-bit using a **clock line** and **chip select (CS)**.

Shaft Encoders

Provide **feedback for motor control**.

Incremental Encoders

- Use optical or magnetic disks with alternating patterns.
- Generate pulses for each segment passed.
- Two sensors (A & B channels) detect **rotation direction** via phase shift.
- Connected to **pulse counting registers** in microcontrollers to avoid constant polling.
- Usually mounted **directly on the motor shaft** for maximum resolution.
- **Do not measure absolute position** — only relative movement.

Absolute Encoders

- Measure **true angular position** using a **Gray-code disk** and sensors.
- Each sensor combination corresponds to a unique shaft angle.
- Only one bit changes at a time, reducing read errors.

Analog-to-Digital (A/D) Converters

- Convert analog signals into digital numbers.
- Key parameters:
    - **Resolution:** bits per value (e.g. 10-bit)
    - **Speed:** conversions per second
    - **Range:** input voltage (e.g. 0–5V)
- Output interfaces: **Parallel** or **Synchronous Serial**
- Often include **multiplexers** to read multiple sensors.