CSCE 452/752 Fall 2024

2. Robot Hardware

TEXAS A&M UNIVERSITY

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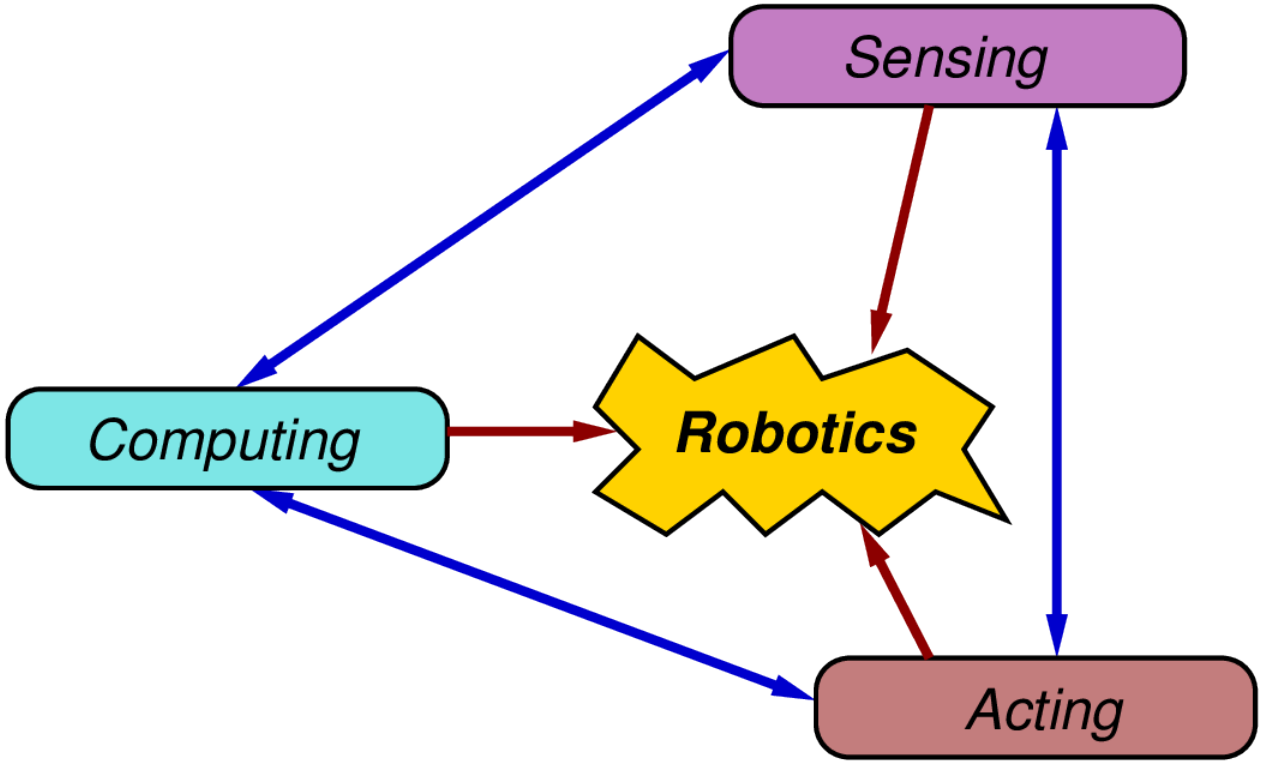
Robot components

Recall from last time: Robotics problems exist at the intersection **computation**, **action**, and **sensing**.



Each of these three elements must be supported by specific hardware.

Types of actuators

- A **DC motor** rotates at a high velocity with low torque and limited control over the amount of rotation.
- A **gearhead motor** has gears attached to a DC motor, decreasing velocity and increasing torque.
- A **stepper motor** rotates in small fixed increments, providing precise control over the amount of rotation.
- A **servo** is a motor equipped with electronics to sense and control the position of the rotor, but without the ability to complete a full rotation.

- **Linear actuators** generate translational motion in various ways.

Modes of locomotion

Locomotion refers to process or means by which robots move through their environments.

There are many modes of locomotion, depending on the environment.

- Terrestrial: wheels, legs, hovercraft, ...
- Underwater: thrusters, flippers, ...
- Airborne: propellers, fixed-wing, ...
- Space: rockets, solar sails, ...

Types of sensors

- **Encoders** measure the amount of rotation in a joint or wheel, often using an **encoder wheel encoder wheel** and an **emitter-detector pair**.
- **Infrared sensors** measure distance by emitting IR light and measuring the intensity of the signal reflected back into the sensor.
- **Ultrasonic (sonar)** sensors measure distance by emitting a pulse of sound and measuring its time-of-flight.
- **Lidar** measures distance using phase shifts in highly coherent light.

Types of sensors

- **Cameras** record the color and intensity of visible light, possibly aided by mirrors of various shapes.
- **RGBD (red-green-blue-depth)** sensors provide images with an additional channel representing the distance to the nearest object in that direction, usually by projecting a pattern of infrared dots onto the scene and measuring the distortion in how the dots appear.

Types of sensors

- **Compasses** measure orientation with respect to Earth's magnetic field.
- **GPS (Global Positioning System) receivers** use satellite signals to determine a device's position on the Earth.
- **Inclinometers** measure the relative direction of gravity.
- **Inertial measurement units** (IMUs) combine 3 accelerometers and 3 gyroscopes to measure linear and angular acceleration.

Active vs. passive sensing

Sensors can be classified as either active or passive.

- **Active sensors** emit energy into or directly modify the environment.
- **Passive sensors** receive energy from the environment.

Proprioception vs. exteroception

Sensors can measure quantities that are either internal or external to the robot.

- **Proprioceptive sensors** provide information about the robot's internal state.
- **Exteroceptive sensors** provide information about what the robot's environment.

Evaluating sensors

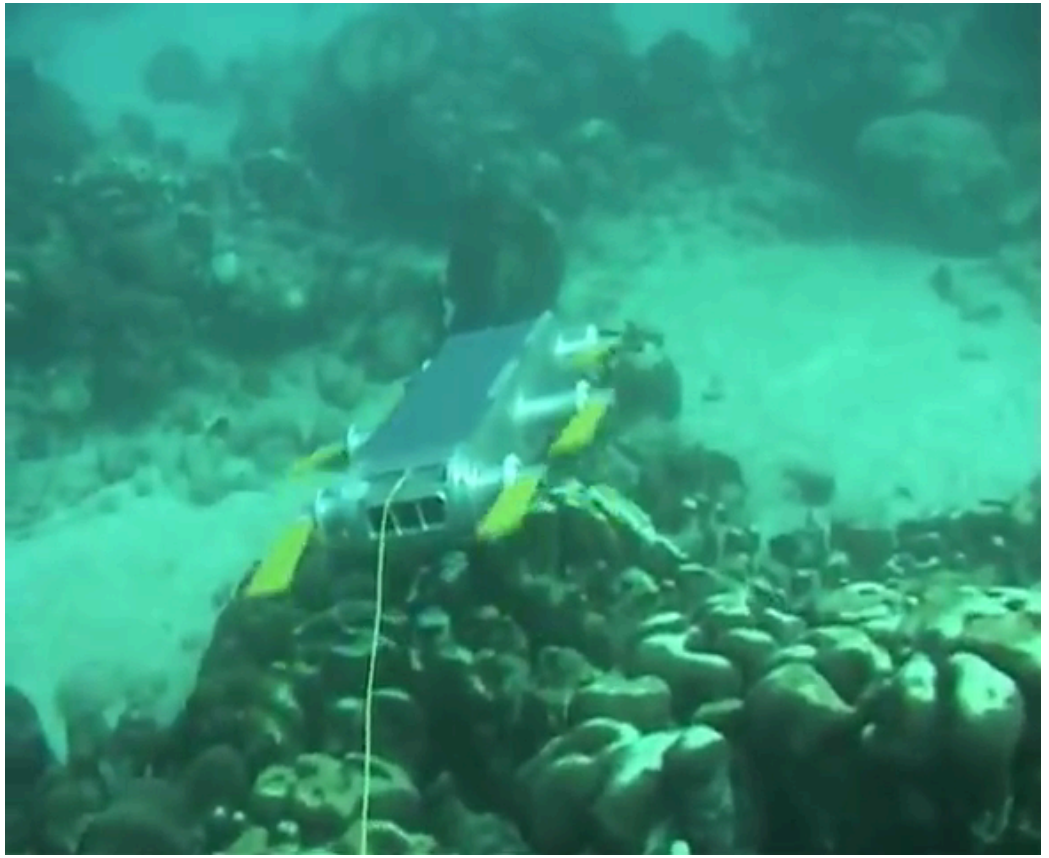
An individual sensor can be judged according to several criteria:

- Speed of operation
- Cost
- Error rate
- Robustness
- Computational requirements
- Power consumption
- Size and weight

Tradeoffs are everywhere!

A good robot design must balance may elements.

- space
- weight
- power
- cost
- durability
- maintainability
- accuracy
- reliability
- ...



Two strategies

When choosing the hardware to include on a robot, we can take at least two different approaches.

Option 1: We can (try to) to **eliminate** issues by adding or improving devices.

Talos, MIT; Kuka manipulator

Two strategies

When choosing the hardware to include on a robot, we can take at least two different approaches.

Option 2: We can choose more modest hardware and design algorithms to make good decisions **in spite of** those limitations.

Roomba, iRobot; Sawyer, Rethink Robotics