Outline

- What is a Sensor?
- Types of Sensors
- What is an Actuator?
- Types of Actuators
- How can sensors and actuators be used?
- Roomba’s Sensors and Actuators
- Behavior-based Robotics
- Sense-Plan-Act Systems
- Sensor and Actuator Code Interfaces
- Exercises
What is a Sensor?

- Something that can detect the environment
- Can help the robot determine
  - Where it is
  - Where other objects are
  - What the present situation looks like
  - Etc.
Human Sensors

- Eyes (sight)
- Ears (hearing)
- Nose (smell)
- Tongue (taste)
- Skin (touch)
- Internal Sensors
  - Know when we are hungry
  - Know when we are tired
  - Know when we are in pain
Types of Sensors

- Sonar
- Infrared
- Ladar
- Wheel Encoders
- Cameras
- GPS
- Microphones
- Bump Sensors
- Other
What is an Actuator?

- Something a robot can use to interact with the environment
- Can move the robot or manipulate the environment
Human Actuators

- Muscles
- Vocal Chords
Types of Actuators

- Drive Motors
- Other Motors
- Speakers
- Lights
- Other
How can sensors and actuators be used?

- Used to understand and interact with the environment
- Can make robots more intelligent
- Can be used to ensure robot safety
Roomba’s Sensors and Actuators

- Drive Motors
- Speaker
- LEDs
- Vacuum/Brush Motors (on some models)
- Wheel Encoders
- Bump Sensors
- IR Wall Sensors
- IR Receivers
- Cliff Sensors
- Buttons
- Wheel Drop Sensors
- Battery/Current Sensors
- Dirt-detection Sensors (on some models)
Roomba Virtual Wall

- Roomba Virtual Wall unit emits a beam that the Roomba can detect
Decision Making

- Robots need to decide what actions to take given sensor input
- Approaches
  - Behavior-Based Approach
  - Sense-Plan-Act (SPA) Approach
Behavior-based Robotics

- Uses sensor data to immediately make actions
- No memory or model of the environment
- Behaviors emerge by combining simple, reactive components
- Quick to react
Behavior-based Robotics

- **Vehicle 1:**
  - One Sensor
  - One Motor
  - Sensor detects light and drives faster when there is more light present
  - Very simple

Example and Diagram taken from Valentino Braitenberg’s *Vehicles: Experiments in Synthetic Psychology*
Behavior-based Robotics

- Vehicle 2a:
  - Two Sensors
  - Two Motors
  - Left Sensor controls Left Motor; Right Sensor control Right Motor
  - Steers away from light sources
  - Cowardly to light

Example and Diagram taken from Valentino Braitenberg’s *Vehicles:Experiments in Synthetic Psychology*
Behavior-based Robotics

- Vehicle 2b:
  - Two Sensors
  - Two Motors
  - Left Sensor controls Right Motor; Right Sensor control Left Motor
  - Steers toward light sources and speeds up
  - Aggressive to light

Example and Diagram taken from Valentino Braitenberg’s *Vehicles: Experiments in Synthetic Psychology*
Sense-Plan-Act Systems

- Maintains an internal model about past experiences and the environment
- Plans actions based on sensory input and memory
Sensor and Actuator Code Interfaces

- `pause(duration)`
  - Roomba will not process any other commands for the specified duration in seconds
- `setStatusGreenLED(status)`
  - Turns on or off the green status LED
- `setStatusRedLED(status)`
  - Turns on or off the red status LED
Sensor and Actuator Code Interfaces

- addSongNote(notenum, duration)
  - Adds a note to the current song
- clearSong()
  - Clears the current song
- playSong()
  - Plays the current song
Sensor and Actuator Code Interfaces

- `getLeftBump()`
  - True if the left bumper has been hit
- `getRightBump()`
  - True if the right bumper has been hit
- `getCliffFrontLeft()`
  - True if a cliff has been detected in the front left
- `getCliffFrontRight()`
  - True if a cliff has been detected in the front right
- `getCliffLeft()`
  - True if a cliff has been detected on the left
- `getCliffRight()`
  - True if a cliff has been detected on the right
Sensor and Actuator Code Interfaces

- `getWall()`
  - True if the IR sensor has detected a wall on the right
- `getVirtualWall()`
  - True if a virtual wall has been detected
- `getLeftWheelDrop()`
  - True if the left wheel has dropped down
- `getRightWheelDrop()`
  - True if the right wheel has dropped down
- `getCenterWheelDrop()`
  - True if the center wheel (front caster wheel) has dropped down
Sensor and Actuator Code Interfaces

- `waitForVirtualWall()`
  - Waits until a virtual wall is detected

- `waitForBump()`
  - Waits until one or more of the bumper sensors are triggered
Exercises

- Write a program that will have the Roomba drive forward until a virtual wall is detected. Have it then turn around and drive forward until a bump sensor is hit. As soon as that happens, make the roomba stop.

```java
import roomba.roombanetwork.services.userservice.*;

public class MyRoombaProgram{

    public static void main(String [] args){
        UserService.setServerAddress("localhost");
        UserService.setName("Your_Name");

        Roomba roomba = new Roomba();

        roomba.forwardSpeed(.3);
        roomba.waitForVirtualWall();
        roomba.turn(180);
        roomba.forwardSpeed(.3);
        roomba.waitForBump();
        roomba.forwardSpeed(0);

        UserService.disconnect();
        System.exit(1);
    }
}
```
Exercises

- Write a program to make the Roomba spin until it has been picked up (the wheels drop). As soon as that happens, stop the motors and make the Roomba play a song.

import roomba.roombanetwork.services.userservice.*;

class MyRoombaProgram{
    public static void main(String [] args){
        User Service.setServerAddress("localhost");
        User Service.setName("Your.Name");

        Roomba roomba = new Roomba();

        roomba.turnSpeed(.3);

        // Wait until the wheels drop
        while (!roomba.getLeftWheelDrop() &&
               !roomba.getRightWheelDrop() &&
               !roomba.getCenterWheelDrop()){
            try{
                Thread.sleep(10);
            } catch (Exception e){
            }
        }

        roomba.turnSpeed(0);

        // Play the song
        // TODO
        roomba.addSongNote(0,1);
        roomba.playSong();
        User Service.disconnect();
        System.exit(1);
    }
}
Exercises

- Write a program to make the Roomba drive forward until it detects something. If an object is detected through the bump sensors, have the Roomba turn around and drive forward for 1 meter. If a virtual wall is detected, have the Roomba turn 90 degrees to the right and stop.

```java
import roomba.roombanetwork.services.user.service.*;

public class MyRoombaProgram {
    public static void main(String [] args) {
        UserServices.setServerAddress("localhost");
        UserServices.setName("Your_Name");

        Roomba roomba = new Roomba();
        roomba.forwardSpeed(.3);

        while (!roomba.getLeftBump() || !roomba.getRightBump() || !roomba.getVirtualWall()) {
            try {
                Thread.sleep(10);
            } catch (Exception e) {
            }
        }

        if (roomba.getLeftBump() || roomba.getRightBump()) {
            roomba.forwardSpeed(0);
            roomba.turn(180);
            roomba.drive(1);
        } else if (roomba.getVirtualWall()) {
            roomba.forwardSpeed(0);
            roomba.turn(90);
        }

        UserServices.disconnect();
        System.exit(1);
    }
}
```
Questions?