CORC 3303 Exploring Robotics

Lecture D
Sensing

- **Topics:**
  1) Perception, Levels of Processing, Simple Sensors.
  2) A look at iRobot's Roomba
  3) RCX's Decision Making based on Sensor Inputs

Sensors are for Perception

- Sensors are physical devices that measure physical quantities.
  - Proprioception and exteroception make up the perceptual system of a robot
  - There are many modalities
- Sensor noise and errors are inherent in physical measurement, thus the challenge of *uncertainty*
- Issues with Sensors:
  - Sensors produce signals, not symbols.
  - *Signal-to-symbol* problem: from sensor input to intelligent response which requires an abstract and symbolic form
- Sensor Fusion: Combining multiple sensors to get better information about the world.

Levels of Processing

- Electronics (low level): such as measuring voltages
- Signal processing (medium level): such as separating voice from noise
- Computation (high level): such as recognizing an object from an image
- Examples:
  - Bump Sensors (low) – odometry (low) – sonar (medium) – speech (medium) – vision (high)
- Simple and Complex Sensors

  Given the sensor input,
  - Both simple and complex sensors can be used to answer the question: what should a robot do? (*action in the world*)
  - Complex sensors can also be used to answer the question: what was the world like? (*reconstruction of the world)*

Simple Sensors

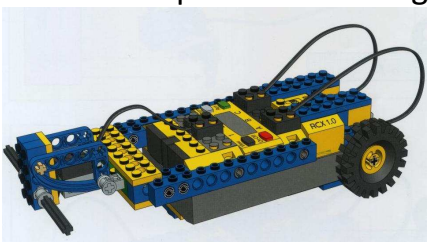
- Sensors that don't require a lot of processing
- Passive vs. Active (applies to both simple or complex)
  - Passive: measures a physical property only, with a detector

    Ex: switches, resistive light sensors, cameras
  - Active: provides own signal/stimulus, with both an emitter and a detector

    Ex: reflectance and break beam, ultrasound and laser.

Switches

- Measuring current to detect an open or closed circuit
- Used as a contact sensor, limit sensor, or shaft encoder sensor.
- Could be implemented as a surface contact or a whisker (antenna) like structure
- A more versatile bumper used in RCX go-bot



Light Sensors

- Photocells convert light intensity to resistance in the circuit
- Work even with invisible light (such as infrared)
- Could be used for measuring intensity, differential intensity or break in continuity
  - Reflectance sensors: active sensors with emitter and detector side by side
  - Break beam sensors: emitter and detector face each other
- Calibration is used to reduce noise

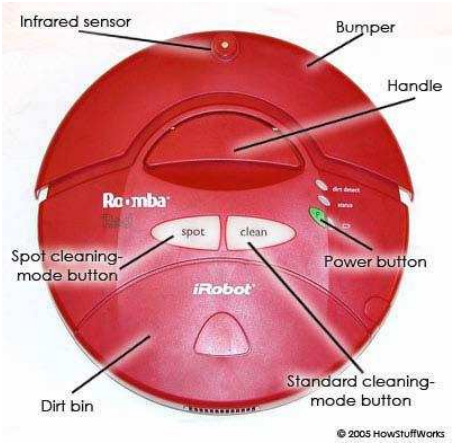
A Look at iRobot's Roomba

- Roomba vacuums your floors and rugs at the press of a button, helping you maintain a cleaner home.

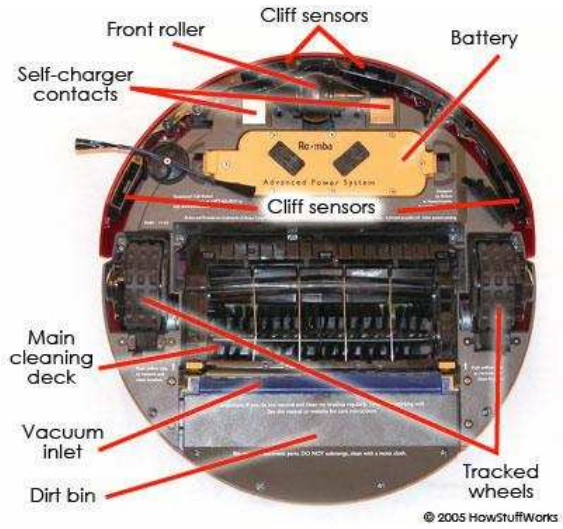
iRobot Roomba® Vacuuming Robot

Top View of a Roomba

- The Roomba Red is approximately 13 inches (33 cm) in diameter and 3.5 inches (9 cm) tall.



Bottom View of a Roomba



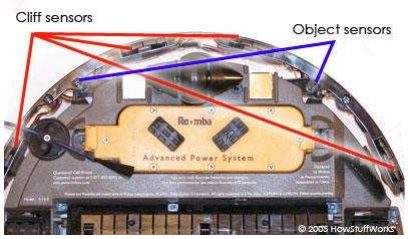
Motors in a Roomba

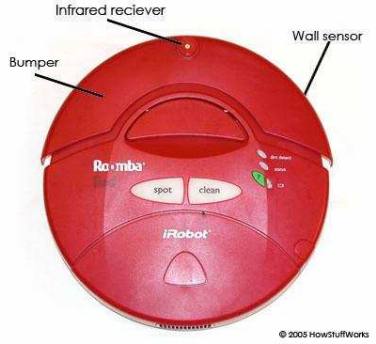
Roomba has a total of five motors:

- One driving each wheel (2 total)
- One driving the vacuum
- One driving the spinning side brush
- One driving the agitator assembly

Sensors in a Roomba

- The **cliff sensors** constantly send out infrared signals, and Roomba expects them to immediately bounce back. If it's approaching a cliff (steps), the signals get lost and the Roomba knows to head the other way.
- When Roomba knocks into something, its bumper retracts, activating mechanical **object sensors** that tell Roomba it has encountered an obstacle. It then backs up, rotates, and moves forward until it finds a clear path.





Sensors in a Roomba, cont.

- The **wall sensor** is located on the right side of the bumper that detects the bounced-off infrared signal sent out from an emitter on the left side. It lets Roomba follow very closely along walls and around objects (like furniture) without touching them.
- It has **dirt sensors** in order to figure out which areas need more cleaning. When the agitator kicks up a large amount of dirt, it causes more vibration when it hits the metal plates of the sensors. The sensors detect that acoustic increase and tell Roomba to go over the area again.

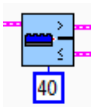
Roomba's Decision Making

- Roomba uses iRobot's AWARE Robotic Intelligence System to make many decisions for itself, so minimal human input is required.
- The AWARE system is made up of multiple sensors that pick up environmental data, send it to the robot's microprocessor and change Roomba's actions accordingly.
- Roomba's sensors allow it navigate your home with relative autonomy.

RCX Decision Making

- Sensory inputs, such as the value of the light sensor, will make the robot a little more intelligent!
- We need a **decision-making** mechanism so that our robots can react to their environment **autonomously** (without a human touching it).
- Decision making is achieved by **conditional execution** in the programming environment.
- In RoboLab, by using **fork** structures, we can allow programs to behave differently based on different values of sensor inputs.

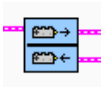
How the light sensor works?



Light Sensor Fork

- The light sensor has a transmitter and a receiver. It transmits infrared light which bounces off objects and then returns in the direction of the receiver.
- The receiver records a value indicating how much light it read, which basically tells you about the brightness of the object that the light sensor is pointing at.
- The light sensor produces a value between 0 and 100, where 100 means very bright and 0 means very dark.

RCX Obstacle Avoidance



Touch Sensor Fork

- **Obstacle avoidance** is a behavior where robots try to avoid bumping into things.
- They do this by bumping into obstacles (to discover that they are there) and then backing up and/or turning around to avoid them.
- A **touch sensor fork** works similarly to a **light sensor fork** - it helps the robot make decisions about how to behave based on input from one of its sensors.