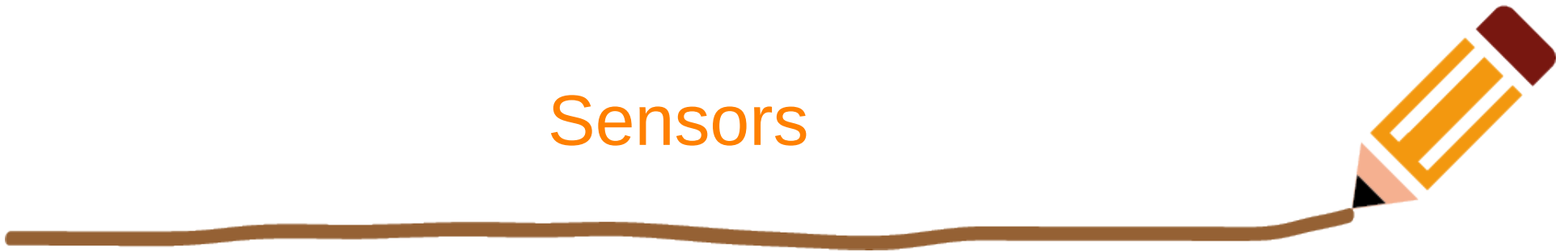
Sensors



Administrative

- Assignment
  - Read chapter 7 (125-141) in your book

Take Home summary about sensors

- Lots of kinds of sensors
- All sensors are noisy – some more error prone than others
- Sensors return an incomplete description of the environment.
- Real sensors can rarely be accurately modeled/simulated.

Know what sense data represents

- Difference sensors return values with different units
  - Some return a raw value
  - Some return in particular unit
    - Know what units are being used
    - Use them consistently
    - Mars orbiter crash
      - https://www.wired.com/2010/11/1110mars-climate-observer-report/
      - Software processing sensor data did so in pounds
      - Software using data assumed it was in newtons
      - Oops crash

Sensors for robots

- In the early days,
  - Bespoke sensors were created for robots
  - Expensive
  - Time consuming
- Today most modern robot sensors were first developed for another industry
  - Transportation
  - Phones
  - Gaming
  - Etc.

Exercise

- Quick Exercise from the book
  - Think about the sensors that you are interacting with daily. What sensors do you have in your phone, in your kitchen, or in your car?
  -

Wring every bit of information

- Wring every bit of that information out of those sensors
  - For example
    - GPS is usually for getting outdoor location
    - What else can you measure with it?

Active vs. Passive Sensors

- Active Sensors
  - Emit some sort of energy into the environment and measure the change/reaction in the environment
  - Common Examples?
    - From those who have worked with sensors before?
- Passive Sensors
  - Measure something (usually energy) already in the environment
  - Common Examples?
    - From those who have worked with sensors before?

Active vs. Passive Sensors

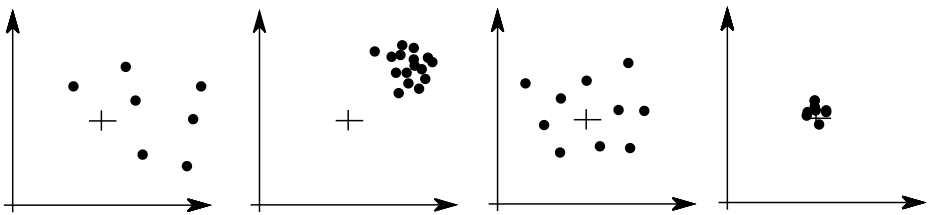
- Active Sensors
  - Emit some sort of energy into the environment and measure the change/reaction in the environment
  - Common Examples?
    - Sonar
    - Lidar
    - Infrared distance sensors
    - RFID
- Passive Sensors
  - Measure something (usually energy) already in the environment
  - Common Examples?
    - Temperature sensors
    - Light sensors
    - Accelerometer
    - Compass
    - Touch (button/whisker)

A bit more Jargon/Terminology

- Range: difference between the upper and lower values the sensor can sense
- Dynamic range: upper/lower value
- Sensor Resolution: the 'distance' (difference) between the smallest two real world values that provide a different value in the sensor
- Sensor Accuracy: The difference between the average sensor value and the actual real world value being measured
- Sensor Precision: statistical variation/range (or in lay terms, does the sensor produce the (nearly) same reading for the same real world conditions

Precision vs. Accuracy

- From your book:
- Figure 7.1. The cross corresponds to the true value of the signal. From left to right:
  - neither precise nor accurate,
  - precise but not accurate,
  - accurate but not precise,
  - accurate and precise.



Proprioception vs. Exteroception

- Proprioception
  - Sensing internal to the agent (robot in our case)
  -
- Give me an example of human proprioception

- Exteroception
  - Sensing the world outside of the agent (robot in our case)
  -
- Give me an example of human exteroception

Proprioception vs. Exteroception

- Proprioception
  - Sensing internal to the agent (robot in our case)
  -
- Give me an example of robot proprioception

- Exteroception
  - Sensing the world outside of the agent (robot in our case)
  -
- Give me an example of robot exteroception

Proprioception in Robots

- Common Proprioception in robots (even relatively inexpensive ones)
  - Motor/Servo encoder. The motor/servo knows what angle the wheel is currently at.
    - Some older or really cheap motors don't but anything over $25 usually does today
  - Accelerometer
    - How fast am I changing movement. How is this useful? What might we measure
  - Gyroscope
    - What is up
      - How is this useful

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  - Accelerometer
    - How fast am I changing movement. How is this useful?
    - Very good for detecting crashes at least
  - Gyroscope
    - What is up
      - How is this useful
    - Am I about to fall over if I keep going on this slope?
  - The first robots we use only have encoders, but the drones have all three

More Proprioception

- Torque sensors : measure how much force is applied
  - Really important for bigger robots, not nearly as much for our smaller ones.
- Touch sensors
  - Whisker & button most common, but put a plate on a button and suddenly you have an "oh no! I hit something sensor"

Exteroception Sensors

- Most commonly used exteroception sensors: Sensors to measure distance
  - All (but one) are active sensors that put energy into the world, then measure the round trip time to reflection is received
  - Most common (in increasing order of both price and accuracy/usefulness)
    - InfraRed (IR) sensors
    - Sonar sensors
    - Lidar (Laser Range Finder) sensors
  - Occasionally use radar or stereo vision on more expensive robots.

Other Common Exteroception Sensors

- There are several other common exteroception sensors used in 'budget robotics'
  - Generally useful for a specific uses rather than generally useful
  - Light sensor
    - Measures the amount of light hitting the sensor
    - Put 'blinders' on it to make it directional.
  - Sound sensor
    - Detects sounds (sometimes in a particular frequency range) in the area
  - Loudness sensor
    - Similar to the sound sensor, but there is a potentiometer to adjust so you can get a value only after a particular volume is hit
  - What might we used these for?