Complex Sensors

SONARs

Levels of Sensory Processing

SONAR
SOund NAvigation and Ranging

- Echolocation
  - Bats
  - Dolphins

Time of flight

- Measure the time it takes a sound to go to an object and bounce back
- Use the speed of sound to compute the distance $D = \frac{R \times T}{1000}$, where $R$ is the rate (speed) of sound.
- Speed of sound at sea level and room temp = 1.12 feet per millisecond = about 600 mph.

Fathometer/Depth Sounder

Sonars Use Transducers

- A transducer transforms one form of energy into another.
- The pinger in SONAR converts electrical energy to acoustic energy (sound) by moving a membrane
- The detector converts acoustic energy to electrical energy
Hertz

- A unit of frequency
- One Hertz means once per second,
- a Kilohertz (KHz) is 1000 Hz and
- a Megahertz (MHz) is 1,000,000 Hz.

The problem of Specular Reflection

- An acoustic ricochet
  - Sound pulse bounces off the surface, but does not return directly to the transducer. Rather, it bounces off other surfaces, taking a long path, before returning to the transducer. This gives an inaccurate (long) reading.
- Factors:
  - Smoothness of the surface
  - Angle of incidence of the sound on the surface
- Fixes:
  - Eliminate smooth surfaces

Specular Reflection Computational Approach

- Long sonar readings can be very inaccurate, as they may result from false reflected readings from nearby objects rather than accurate faraway readings.
- Let the robot accept short readings but do more processing on the long ones.
- For example, keep a history of past readings, and see if they get longer or shorter over time in a reasonable, continuous way.
  - if they do, the robot can trust the readings
  - if not, the robot assumes they are due to specular effects, and disregards the readings

But wait!

- What if there is a strong discontinuity in the environment?
- The edge of a wall, for example
- The ranges now change very suddenly from short to long
- The robot should not disregard THAT!

Action-oriented Perception

- Whenever the robot receives an unexpected long sonar reading that seems strange/unlikely,
- it can turn and/or move so as to change the angle between its sonar sensor and the environment,
- and then take another reading, or many more readings, to maximize accuracy.
- This is Action-Oriented Perception:
  - Using action to improve sensory information
  - It is a powerful method of dealing with uncertainty in robotics.