Unit D

Sensing and Perception

Exploring Robotics
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Why does a robot need sensors?

- the environment is complex
- the environment is dynamic

Sensors enable the robot to learn about *current* conditions in its environment.
What kind of information does a robot need?

Examples

- contact
What kind of information does a robot need?

**Examples**

- contact
- obstacles
What kind of information does a robot need?

Examples

- contact
- obstacles
- texture of terrain
What kind of information does a robot need?

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- contact
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- distance to objects, size of objects
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**Examples**

- contact
- obstacles
- texture of terrain
- distance to objects, size of objects
- object recognition
What kind of information does a robot need?

### Examples

- contact
- obstacles
- texture of terrain
- distance to objects, size of objects
- object recognition
- robot’s own orientation (heading, tilt)
What kind of information does a robot need?

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What kind of information does a robot need?

Examples

- contact
- obstacles
- texture of terrain
- distance to objects, size of objects
- object recognition
- robot’s own orientation (heading, tilt)
- odometry
- location
Sensor categories

- Proprioceptive sensors provide information about the robot’s own body, especially the positions of its parts in relation to each other:
  - angles of its joints
  - positions of its servo motors
  - direction “head” is facing relative to the body
  - is it standing, sitting, lying on its back?

- Interoceptive sensors provide information about the robot’s internal condition:
  - battery condition
  - internal temperature

- Exteroceptive sensors provide information about the external environment:
  - presence/location of other objects in its surroundings
  - sound and other broadcast signals (e.g. communication)
Sensor categories

- **Passive sensors** measure signals provided by the environment
- **Active sensors** emit their own signals and measure their interaction with the environment
Sensors

Examples

- switches (electrical current: on or off)
- light sensors (photocells: resistance low when illuminated)
  - passive: ambient light
  - active: infrared
- cameras
- sonar (emit sound, measure reflected signal)
- radar (emit radio waves, measure reflected signal)
- laser (emit coherent light, measure reflected signal)
- accelerometers (measure acceleration and orientation)
- compasses (measure orientation wrt magnetic field)
- altimeters (measure air pressure)
Noise and Uncertainty

In the physical world, every measurement involves estimation.

Sources of uncertainty

- measurement errors
- sensor noise
- sensor resolution
- effector/actuator noise
- incomplete knowledge about environment
- environmental conditions (hidden or partially observable state)
State

- a description of a system in terms of parameters or attributes
- a set of values of the variables in a mathematical model
- a unique configuration (snapshot) of the information in a program or machine

Do sensors provide state?
Sensing vs. Perception

Perception requires:
- sensor data
- signal processing
- computation

**Perception:**
understanding of sensory information
Reconstructing the world is too hard.

**Ways to reduce computational cost:**

- action-oriented perception ("need to know")
- expectation-based perception (use knowledge about environment)
- task-driven *attention*
- perceptual classes (Goldilocks)
Vision

What does vision entail?

- babies do it
- insects do it

What’s so hard about vision?
Human Eye

Fig. 1.1. A drawing of a section through the human eye with a schematic enlargement of the retina.

About 126 million light-sensitive cells in the retina.
A few hundred thousand (or a few million) photocells in the camera.
A camera image is made up of pixels.
RGB Color Space
An Aibo’s-eye view of the field
Image representation in the robot

Image segmentation

- thresholding
- scan for values within a range
- ...

Sensing and Perception

Sensing
- Sensors
- Uncertainty
- State

Perception

Vision

RoboLab
- Loops and Jumps
- Conditional Branches
Loops and Jumps

Conditional:

-----------Loop--------------

All code between these icons will execute 'n' times.

Unconditional:

Land

Code here will execute an "infinite" number of times.

Jump
Conditional Branch: Touch Sensor Fork

Not so useful:

Much better:
Conditional Branch: Light Sensor Fork

Not so useful:

![Diagram](image1)

Much better:

![Diagram](image2)