Sensing 1
Intro to Sensors

Many slides adapted from slides © R. Siegwart, ETH Zürich – Autonomous Systems Laboratory

Bookkeeping

- Today
  - Quiz
  - Assignment 1 – posted from class schedyle
  - Group meetings well underway
  - Sensors and characterization
- Next time
  - Representing uncertainty
  - Remaining sensors
  - Cameras pt. 1
- Read SNS 4.2.1 – 4.2.3 (p. 142-159)

Quiz

- All collected at once
- Allowing 15 minutes (for calibration)
  - When I say stop, please do.
- Will be returned Thursday
  - 24-hour cool-off period for questions

Classification of Sensors

- Proprioceptive sensors
  - Measure values internally to the system (robot),
  - Examples: motor speed, wheel load, heading, battery status
- Exteroceptive sensors
  - Retrieve information from the robot's environment
  - Examples: distances to objects, intensity of ambient light

Classification of Sensors

- Passive sensors
  - energy coming for the environment
- Active sensors
  - emit their proper energy and measure the reaction
  - better performance, but some influence on envrionment

Classification of Sensors

- Incremental sensors
  - Reports an incremental change (up/down, warmer/cooler)
  - Does not know starting state when powered up
  - Requires calibration
- Absolute sensors
  - unambiguously reports its state
    - Within a known scale or range
  - When powered up, reports state
  - No need for any reference information

General Classification (1)

General classification (typical use)	Sensor Sensor System	PC or EC	A or P
Tactile sensors (detection of physical contact or closeness; security switches)	Contact switches, bumpers	EC	P
	Optical barriers	EC	A
	Noncontact proximity sensors	EC	A
Wheel/motor sensors (wheel/motor speed and position)	Brush encoders	PC	P
	Potentiometers	PC	P
	Synchros, resolvers	PC	A
	Optical encoders	PC	A
	Magnetic encoders	PC	A
	Inductive encoders	PC	A
	Capacitive encoders	PC	A
Heading sensors (orientation of the robot in relation to a fixed reference frame)	Compass	EC	P
	Gyroscopes	PC	P
	Inclinometers	EC	A/P

A, active; P, passive; P/A, passive/active; PC, proprioceptive; EC, exteroceptive.

General Classification (2)

General classification (typical use)	Sensor Sensor System	PC or EC	A or P
Ground-based beacons (localization in a fixed reference frame)	GPS Active optical or RF beacons Active ultrasonic beacons Reflective beacons	EC EC EC EC	A A A A
Active ranging (reflectivity, time-of-flight, and geo-metric triangulation)	Reflectivity sensors Ultrasonic sensor Laser rangefinder Optical triangulation (1D) Structured light (2D)	EC EC EC EC EC	A A A A A
Motion/speed sensors (speed relative to fixed or moving objects)	Doppler radar Doppler sound	EC EC	A A
Vision-based sensors (visual ranging, whole-image analy-sis, segmentation, object recognition)	CCD/CMOS camera(s) Visual ranging packages Object tracking packages	EC	P

Range and Resolution

- Range
  - Upper limit, lower limit
  - For a rotation sensor, range is..?
- Resolution
  - Minimum measurable difference between two values
  - Usually: lower limit of *dynamic range* = resolution
  - For digital sensors it is usually the A/D resolution.
    - e.g. 5V / 255 (8 bit)

Linearity and Bandwidth

- Linearity
  - variation of output signal as function of the input signal
  - linearity is less important when signal is after treated with a computer
- Bandwidth or Frequency
  - the speed with which a sensor can provide a stream of readings
  - usually there is an upper limit depending on the sensor and the sampling rate
  - Lower limit is also possible, e.g. acceleration sensor

Sensitivity

Characteristics that are especially relevant for real world environments

- Sensitivity
  - How much change in world affects change in sensor readings
  - Ratio of output change to input change
  - High sensitivity often correlated to high cross-sensitivity
- Cross-sensitivity
  - Sensitivity to environmental parameters unrelated to target parameters
  - In a real world environment, a sensor has very often high sensitivity to confounding environmental changes
    - Example: Illumination