Sensors
Guide to Robotic Sensing
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What are Robot Sensors for...

- Perception
- Feedback
- To create an intelligent system
  - Automation (simple reaction) vs Robotic Intelligence (reasoning/calculation)
Robot Examples

- Braitenberg vehicles
  - Simple behavior based AI
  - Primitive sensors (such as light sensing) connected to motors
  - Hide or move towards light
  - Simple goes a long way
Typical Ways to get Data

- Discrete on/off signal
  - Simply read True/False value from pin on port
- Analog signal
  - Analog Signal is connected to ADC channel and ready in as a quantized discrete value
- Serial UART/RS232/RS485
  - Signals sent between two UART type devices via RX and TX communication lines
  - Devices vary in rate, setup, voltage, etc.

Typical Ways to get Data Cont.

- Pulse-Width Modulation (PWM)
  - Send a pulse chain of digital data to an analog device
  - Chain of data is used to send data or to specify desired frequencies of a signal
- Input Capture
  - Using timers, record when a sensor device changes value, resulting in a desired source of data
Typical Ways to get Data Cont.

- I2C
  - 2-wire Multi Master serial single ended communication with devices specified by address
- SPI
  - 3-wire (4-wire) Synchronous serial communication between master and slave devices chosen by a select line
- Description of both
  - [https://sites.google.com/site/controlandelectronics/i2c-spi-tutorial](https://sites.google.com/site/controlandelectronics/i2c-spi-tutorial)

Typical Ways to get Data Cont.

- High Level Programming
  - High Learning Curves, but more capabilities
- OpenCV
  - Exists as C/C++/Python libraries that may be used
  - Allows high level computer vision algorithms
- Android
  - Useful controls or feedback between robot and phone/tablet
Optical and Light

- Sensors result in data in the form of
  - Color
  - Shape
  - Distance
  - Brightness/Intensity
- Used for
  - Recognizing/tracking objects
  - Obstacle avoidance
  - Ambient light
  - Movement
IR Rangefinder

- IR Transmitter/Receiver combo to detecting distance to objects
- 4 – 150cm range
- Varies due to lighting
  - Sunlight interferes
- Can be purchased or made
- Typically read by Analog (ADC) values.
- May be purchased through
  - [http://www.sparkfun.com](http://www.sparkfun.com) ~$15
  - Purchase with cable ($1.50)
  - [http://www.ebay.com/](http://www.ebay.com/) ~$5.68

LIDAR-Lite V2

- Optical distance measuring device
- Max range 40 meters
- 500 readings per second
- I2C or PWM
- [https://www.sparkfun.com/products/13680](https://www.sparkfun.com/products/13680)
  - $14.95 (out of stock as of Jan 11)
Motion Sensor (pyroelectric)

- Passive infrared Sensors
- Detects “moving” heat
- Typically read by Analog (ADC) values or discrete values
- May be purchased through
  - http://www.sparkfun.com ~$10
  - http://www.ebay.com/ $1.45

CdS – Light Intensity

- Measure Light Intensity in area
- Varies resistance based on light intensity
- Used in simple to complex designs
- Read by Analog (ADC) values
- Very cheap
- May be purchased through
  - http://www.digikey.com ~$2
  - http://www.adafruit.com/products/161 ~$1
  - http://www.ebay.com/ 10 for $2.49
Camera – IP Camera

- Internet Protocol Camera
- Wireless
- Color and Object Detection/Tracking, Object Recognition, Face Detection, etc.
- Higher learning curve, more capable
- Requires high level computer (laptop, embedded board) to process video
- Cameras cost between $40 - $150 (Amazon)

Web Camera

- Color and Object Detection/Tracking, Object Recognition, Face Detection, etc.
- Higher learning curve, more capable
- Requires high level computer (laptop, embedded board) to process video
- Faster frame rates possible vs IP camera
- ~$5-$80
Tactile

Touch
- Sensors that are used as simple tactile response, bump or force gauges
- Each of these give an idea on what the robot touches during movement
- Used for
  - Acknowledging a desired input
    - Volume, keypads
    - Yes/No responses
  - Acknowledge once a limit has been met
    - Mechanical moving systems
  - Alert if something is happening that is not desired
    - Bump sensors
Switch

- Simplest Sensor
- Extremely Cheap
- Easy to implement (basic Digital Logic)
- Used as
  - Input for devices
  - Bump Sensors
  - Limit Switches
  - Available in lab
- Typically read by **Discrete** on/off value
- Watch out for bouncing

Pressure/Force

- Measures pressure or force by varying **resistance** of a flat sensing area
- May be a circular or flat area
- Precision varies based on device
- Used as
  - Force Feedback to device
  - Grippers
  - Weight Measurement
- Typically read as **Analog** (ADC) values
- May be purchased through
  - [http://www.sparkfun.com](http://www.sparkfun.com) ~$8 - $20
Human Input w/o Human Presence

Sound
Sound

- Sensors that supply a device with the auditory environment
- Sensors such as Microphones
- Typical robot applications use simple Piezoelectric sensors

Microphone

- Various types
- Requires amplification, filtering, digitization (typically bought with circuit)
- Usually omni-directional
- Used as
  - Auditory Acknowledgement
  - Digital Signal Processing
- Typically read as Analog (ADC) values
- May be purchased through
  - http://www.sparkfun.com ~$7.95
  - http://www.ebay.com/ $0.99
Sonar Rangefinder

- Use sound to detect distance to objects
- 5 – 6000cm
- Varies in Beam Width and Distance
- Returns affected by surface and environmental factors
- Used as
  - Distance Sensors
  - Typically read by **Analog (ADC) or Serial**
- May be purchased through
  - [http://robot-electronics.co.uk](http://robot-electronics.co.uk) ~$25
  - [http://www.sparkfun.com](http://www.sparkfun.com) ~$28
  - [http://www.ebay.com](http://www.ebay.com/) $2.95
Movement/Position

- Each of these give an idea on the robots attitude or position
- Data may be precise or an estimate
- Sensors such as Encoders, GPS, Tilt Switch, Gyro, Accelerometer, Magnetometer
Encoders

- Count the RPMs of wheels
- Discrete sensor
  - not digital, it is a continuous time sensor
- Use for general positioning, not exact
  - Dead Reckoning
- Typically read using **Input Capture**

Tilt Switch

- Easy to use
- Metal or Mercury
- Typically used in groups
  - More accuracy
- Typically read as **Discrete on/off**
- Cheap ~$1
GPS

- Give semi accurate position of robot
- Useful for waypoint movement or cooperative control
- Typically read as **Serial** or **I2C**
- May be purchased through
  - [http://www.sparkfun.com](http://www.sparkfun.com) ~$50

Gyro

- Positioning, tilt, roll
- 2-3 Axis
- Used as
  - Orientation Sensor
  - Tilt Sensor
- Typically read as **I2C** or **SPI**
- [http://www.sparkfun.com](http://www.sparkfun.com) ~$30
**Accelerometer**
- Measure acceleration in various directions
- Varying ranges
  - +/- .5g to +/- 250g
- Up to 3 axis
- Used as
  - Speed Calculation
  - Directional Feedback
  - Dead Reckoning Sensor
- Typically read as **I2C** or **SPI**
- [http://www.sparkfun.com](http://www.sparkfun.com) ~$10

**Magnetometer/Compass**
- Measure magnetic poles to calculate compass values
  - find heading
- Strongly affected by Magnetic sources
- Typically read as **I2C**
- [http://www.sparkfun.com](http://www.sparkfun.com) ~$15
- [http://www.ebay.com/](http://www.ebay.com/) $1.03
Inertial Measurement Unit

- AKA AHRS
- Usually 9 DOF
- Complete picture of RPY
- [http://www.sparkfun.com](http://www.sparkfun.com) ~$30

Intertial Navigation System

- IMU with velocity (typically GPS)
Feeling/Environmental

- These sensors give the robot an idea as to the environment around the vehicle
- Sensors such as Thermistor or Hall Effect
- Capability for sensing heat (fires) or magnetic sources (pick up magnets)
Soil Moisture

Thermistor
- Measure temperature sources (heat, cold)
- Range of 0 to 100 degrees Celsius
- Easy to implement
- Typically read as *Analog (ADC) values*
- Cheap < ~$1
Hall Effect

- Measure Current or Magnetic sources
- Useful for detecting magnetic objects
- Used as
  - Magnetic Switches
  - Metal Detectors
- Cheap < ~$2

Custom Sensors
Moisture Sensor

DIY Proximity Sensor
Optical Heart Beat Sensor

Laser Communication
Non-Contract IR Thermometer

- Tutorials on hacking
- Cheap ~$35

Custom Sensors

- You can make your own sensors using parts or combinations of the previously mentioned sensors
- Stripped/Modified Roombas
  - Bump Sensors
  - Poor-mans LIDAR
- Neato LIDAR
  - ~$75 at ebay
Sites to Use

- www.sparkfun.com
- www.digikey.com
- www.pololu.com
- www.trossenrobotics.com
- www.robotshop.com
- www.mcmaster.com
- www.hobbyking.com
- www.ebay.com