Sensors

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Connecting to sensors

- Connected to a PC
  - USB
  - Bluetooth
  - RS232 serial
  - Parallel
  - Analog adapters
- Connected to a microcontroller (ex: an Arduino)
  - I²C
  - SPI
  - Analog lines
  - Low-voltage RS232 serial
Properties of a Sensor

- Span – full range
- Transfer function – mapping from actual to measured value
  - May be neither linear or logarithmic
- Accuracy or Resolution – error on measured value
- Repeatability – stability of measured value
- Hysteresis – change in measured value based on direction of change
- Saturation – non-linearity at end of range
Movement in Free Space

- **Accelerometer**
  - Acceleration, not velocity or position
  - Can be used to estimate 'down' due to gravity
- **Magnetic compass**
  - Estimate of “north”, but not when near magnets
- **Gyroscope**
  - Rotational acceleration
- **GPS**
  - Expect 2-100m accuracy outdoors
Tactile Switch

Microswitch

http://team358.org/files/programming/ControlSystem2009-/LimitSwitch.jpg
Photo Interrupter

http://en.kodenshi.cn/imageRepository/03832042-03a4-4cda-ab4d-3c1e6b8444b5.jpg
Reflective Proximity Detector

Light Sensor

Computer vision on arbitrary video is hard!

https://portfolio.du.edu/pc/port?portfolio=gwu4
What the WiiMote sees
Capacitance between two points is affected by:
- Size of electrodes
- Distance between electrodes
- “Relative static permittivity” or “dielectric constant” of material between electrodes
- Proximity
- Touch
- Distance
- Fluids
Piezoelectric

- Impact
- Change in force
- Vibration

Piezoresistive Strain Gage

http://www.astericconsulting.com/clients/Lambda/images/foil_fiber_strain_gages.JPG
Bend/Flex Sensor

http://www.tacticalmarcomms.com/assets/1314722137.jpg
In-Air Sensors

- Humidity
- Ambient pressure
- Gas partial pressure
  - $\text{CO}_2$ or $\text{O}_2$
- Particulates
  - Smoke
- Acoustic
  - Microphones
  - Ambient volume
  - Ultrasonic

http://www.meas-spec.com/uploadedImages/Sensor_Types/Humidity/Products/IMG_HumiditySensor_HS1101LF.jpg
Other Sensors

- Temperature
- Sound or light time-of-flight
  - Good for measuring absolute distance
- pH sensors
- Force-sensitive resistors
- RF power measurements
- Integrated optical flow IC's for movement
- Fluid flow rate
- Fluid pressure
- RFID
Overall Approach

- Figure out what you want to measure
  - Convert an action/event/concept into one or more low-level measurements
  - See how others have handled it
- Look at availability of sensors
- Consider sources of error
  - Sampling speed too low
  - False triggering or saturation (light sensor in sunlight)
- Constrain conditions if possible
- Use complex post-processing if needed
Suppliers

- Mouser.com
- Digikey.com
- Sparkfun.com
Chess Example
Sensors

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Transfer function – the human eye/ear/etc is weird.
Accuracy = close to truth
Precision = repeatable
Giant List of Sensors
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  - Expect 2-100m accuracy outdoors
Microswitch

- Click to add an outline
Photo Interrupter
Rotary Encoder
Reflective Proximity Detector

Photoresistors are slow
Photodiodes are hard to deal with
Phototransistors are better – can still be blinded
Smart ICs are best
Computer vision on arbitrary video is hard!

https://portfolio.du.edu/pc/port?portfolio=gwu4
What the WiiMote sees
Hall Effect

Capacitance

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Say you wanted to make a chess board that tracks the game:

The general case is hard!
Unique pieces

Only one piece moves method
Easier!
Light