Sensors

Chapter 5

Sample of everyday sensors

+GPS

www.qualcomm.com

Camera

US

3D

PIR

Radar

So far: Robotics always benefits, never drives sensor development

Sample application: Mapping

https://www.youtube.com/watch?v=dIiqAFzgslM

Sensors on Sparki

- Accelerometer
- Magnetometer
- Rate gyroscope
- Floor sensor
- Ultrasound sensor
- IR receiver
- Light sensor
- NO Encoders due to Stepper Motor

Which of these sensors can be used to reduce odometry error?

Improving Odometery

- Accelerometer: double-integrate acceleration
- Magnetometer: fix bearing
- Rate gyroscope: integrate rotational velocity
- Floor sensor: identify landmarks
- Ultrasound sensor: identify landmarks
- Receive location via IR receiver
- …

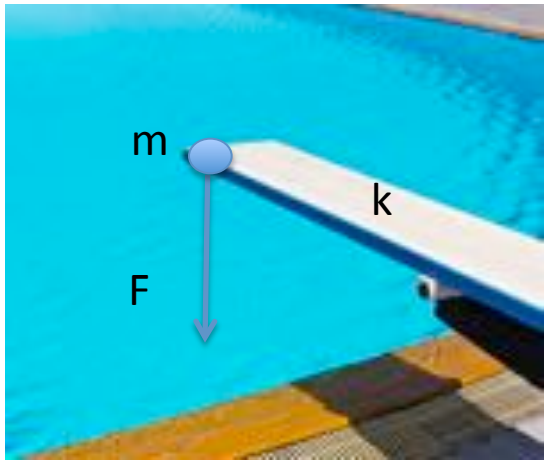
Few (any?) sensors have specific applications, but most problems benefit from as much information as possible.

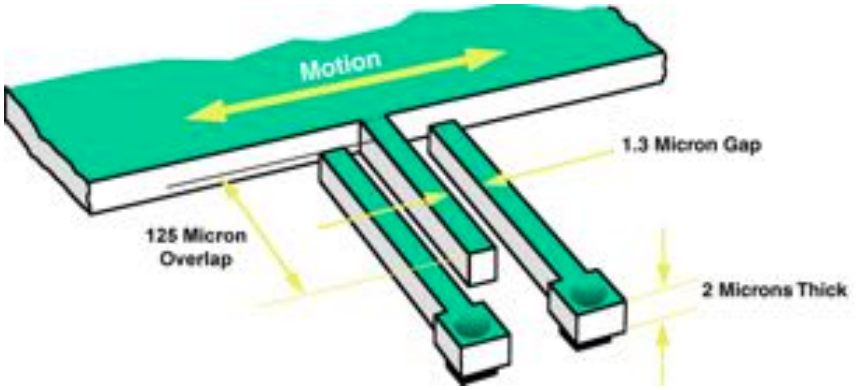
Classifying sensors

- Type of information
- Physical Principle
- Absolute vs. derivative
- Amount of information (Bandwidth)
- Low and high reading (Dynamic range)
- Accuracy and Precision

Accelerometer

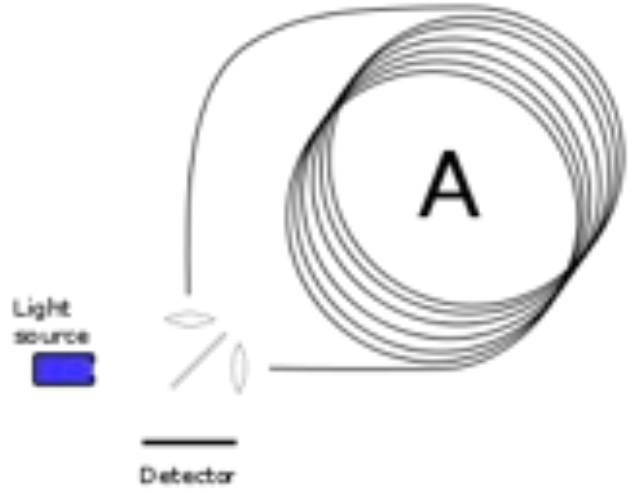
- F=kx=ma
- Very cheap and small
- Measures *acceleration*
- Integrate for speed and distance
- Applications
  - Tell the pose of an object from the direction of gravity
  - Tell when robot hits an object



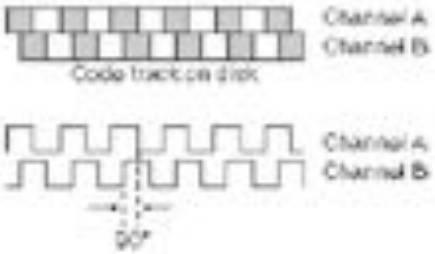


Gyroscopes

- Measures orientation
- Very expensive, infeasible to miniaturize
- *Rate* gyroscopes measure rotational speed
- Implemented using MEMS vibration devices, measure Coriolis force
- Applications
  - Correct heading

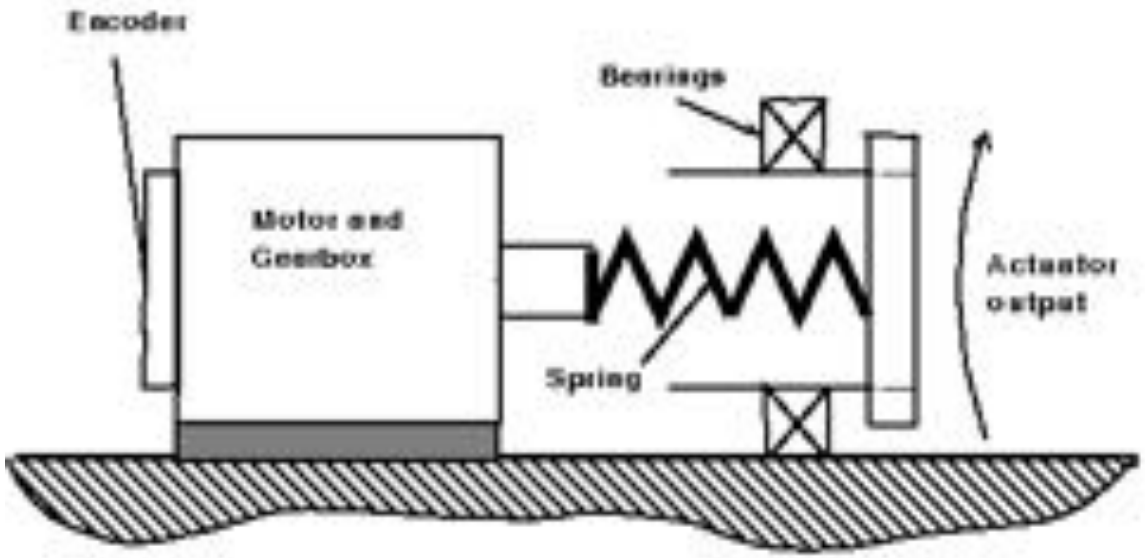


Wheel/Joint encoder



Can also be implemented magnetically or electrically (same principle). Main stream technology: CNC machines and RC servos.

Series Elastic Actuator

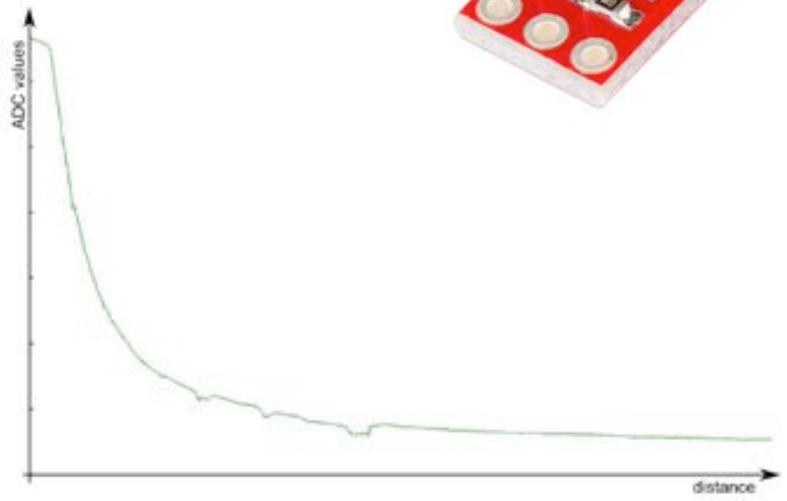


F=kx (Hooke's law)

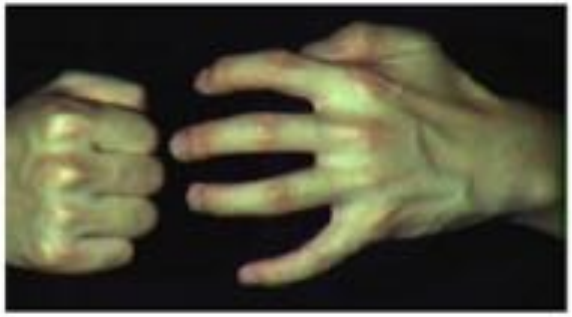
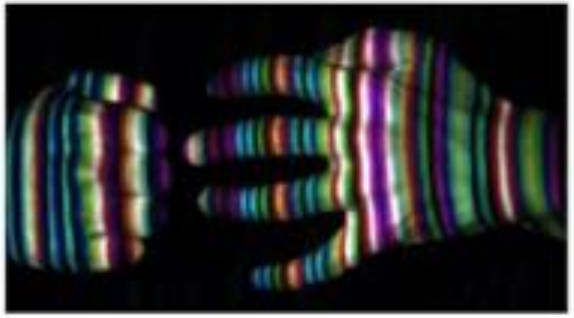
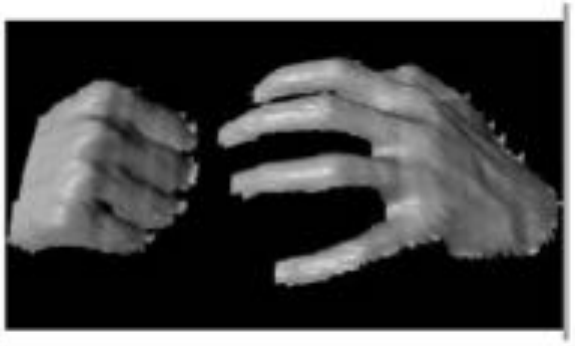
Measure distance using potentiometer

Distance from light intensity

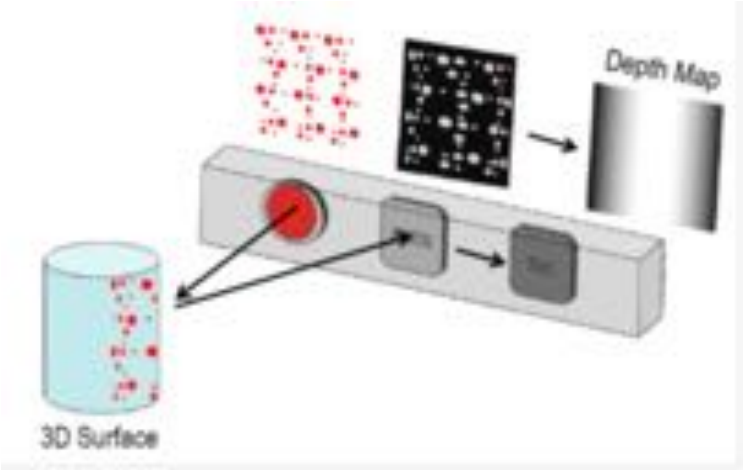
- Emitter/receiver pair
- Highly non-linear
- Depends on surface color
- Confuses emissions from other sensors
- Requires a lot of energy



Distance from structure

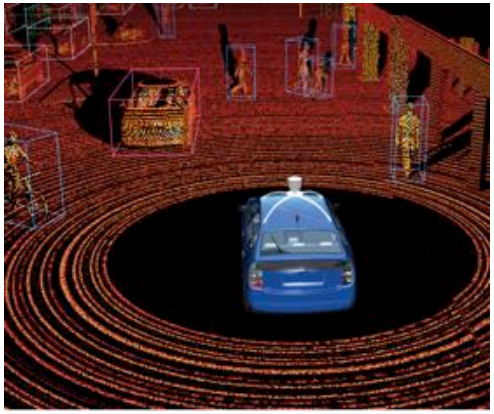




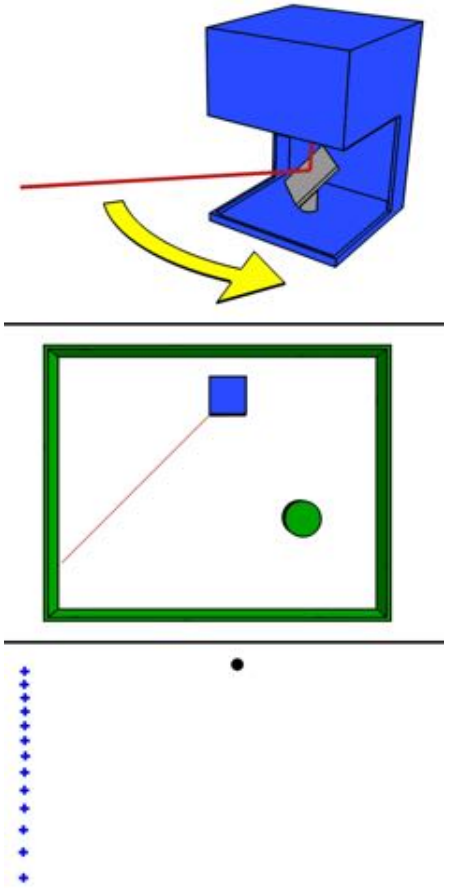
Zhang et al. (2002)



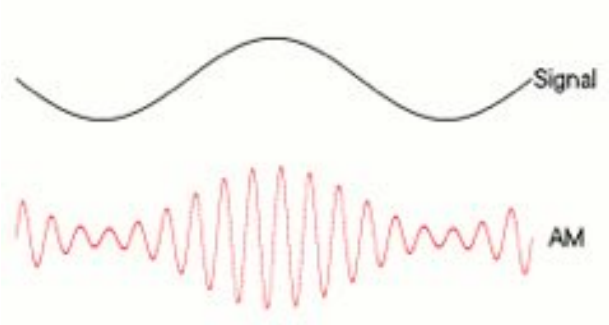
http://www.depthbiomechanics.co.uk/?p=100

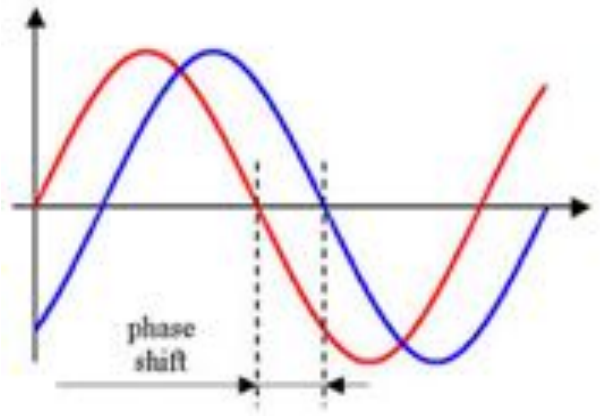
Distance from phase shift





5 Mhz ~ 60m





https://en.wikipedia.org/wiki/Lidar

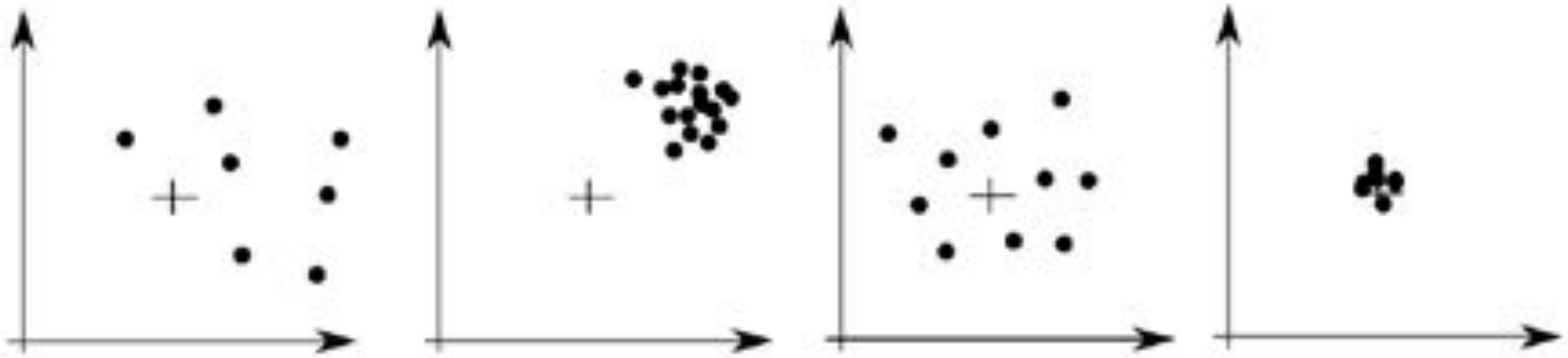
Distance from Sound

- Emitter/receiver pair
- Algorithm
  - Emit ping
  - Measure time until it returns
  - Calculate distance based on 300m/s
- Requires large objects
- Quality of result depends on object size

Sensor characteristics

- Active and passive
- Resolution
- Accuracy
- Precision
- Bandwidth
- Range
- Dynamic Range
- Cross-sensitivity

Precision vs. Accuracy



Neither precise nor accurate, precise and not accurate, accurate and not precise, precise and accurate

Exercise: performance of a laser scanner

- *Range:* difference between highest and lowest reading
- *Dynamic range*: ratio of lowest and highest reading
- *Resolution*: minimum difference between values
- *Linearity*: variation of output as function of input
- *Bandwidth*: speed with which measurements are delivered
- *Cross-Sensitivity*: sensitivity to environment
- *Accuracy*: difference between measured and true value
- *Precision*: reproducibility of results

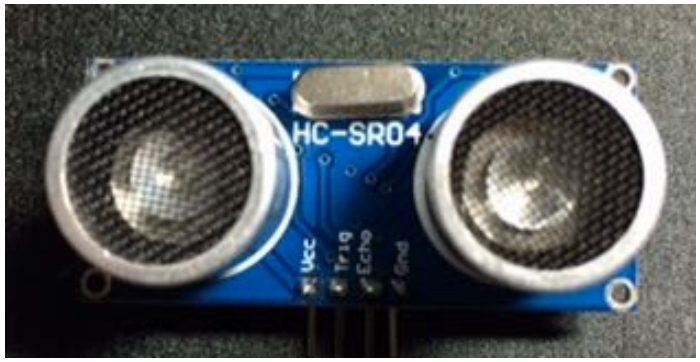
Hokuyo URG

Specification	URG-04LX
Power source	Regulated 5V ±5%
Interface	RS232, USB
Detection Distance	20 to 4000 (mm)
Guaranteed Accuracy (min to 1m)	±10mm
Guaranteed Accuracy (1m to max)	1% of detected distance

Specifications	
Power source	5V +/-5%
Current consumption	0.5A (Rush current 0.8A)
Detection range	0.02 to approximately 4m
Laser wavelength	785nm, Class 1
Scan angle	240°
Scan time	100msec/scan (10.0Hz)
Resolution	1mm
Angular Resolution	0.36°
Interface	USB 2.0, RS232
Weight	5.0 oz (141 gm)

Exercise: performance of an ultrasonic sensor

- *Range:* difference between highest and lowest reading
- *Dynamic range*: ratio of lowest and highest reading
- *Resolution*: minimum difference between values
- *Linearity*: variation of output as function of input
- *Bandwidth*: speed with which measurements are delivered
- *Cross-Sensitivity*: sensitivity to environment
- *Accuracy*: difference between measured and true value
- *Precision*: reproducibility of results



- Power Supply :+5V DC
- Quiescent Current : <2mA
- Working Currnt: 15mA
- Effectual Angle: <15°
- Ranging Distance : 2cm – 400 cm/1" - 13ft
- Resolution : 0.3 cm
- Measuring Angle: 30 degree
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm

Summary

- Sensors do not serve specific applications and no sensor solves a problem completely
- Sensors observe the same phenomenon using different physical principles
- Different sensors have different trade-offs qualified in their different precision, accuracy, bandwidth, dynamic range and resolution
- There are smart ways to extract the desired information from a set of sensors and fuse them