ECGR4161/5196 – Lecture 3 – May 31, 2012

PARO "Baby Harp Seal Robot(?)"
http://www.youtube.com/watch?v=oJq5PQZHU-I&NR=1&feature=fvwp

LegoMindstorm – Rukic's Cube solver:
http://www.youtube.com/watch?v=3QOvEG27Gt4

Tree climbing robot:
http://www.youtube.com/watch?v=zmqDePXM89Y&feature=player_embedded

Today:

- Presentations
- Locomotion
- Lab time

Types of Gears

- Spur Gears
- Helical Gears
- Worm Gears
- Rack and Pinion gears

http://www.geardesign.co.uk/spur-gears.htm

- Bevel and Miter Gears

Carson Carpenter

http://www.premier-gear.com/worm_gears.htm

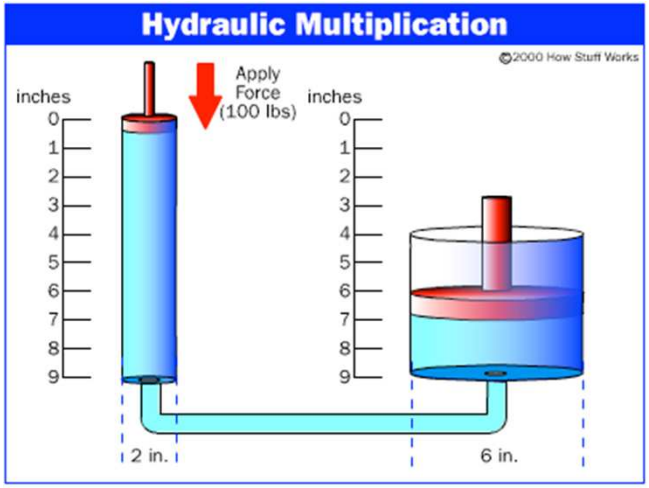
Hydraulics

- Linear actuators that use liquid in order to pressurize a movable piston.
- This fluid is sent from a hydraulic pump through hoses to the cylinders.
- Capable of lifting high amounts of weight.
- Oil is often used because it is very hard to compress.
- Pascal's Principle- pressure exerted on a fluid is distributed equally throughout the fluid.
- If pressure stays constant –

$$F1/A1 = F2/A2$$

$$F2 = (F1*A2)/A1$$

http://ffden-2.phys.uaf.edu/212_spring2005.web.dir/annie_weber/page2.html



http://ffden-2.phys.uaf.edu/212_spring2005.web.dir/annie_weber/page2.html

http://www.ehow.com/how_7589692_do-project-robotic-arm.html

Pneumatics

- It's a technology that deals with the study and application of pressurized gas to effect mechanical motion.
- Pneumatic systems are commonly combined with electrical components.
- Applications:
  - Dentistry
  - Mining
  - Petrochemical industry
  - Defense
  - Entertainment

http://www.articlesbase.com/advertising-articles/pneumatic-jackhammers-251199.html

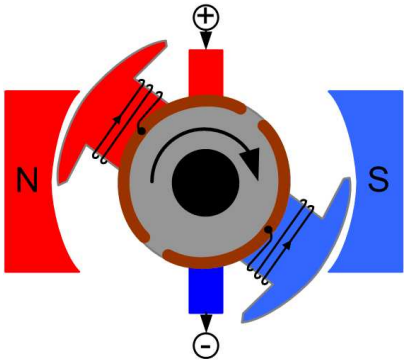
DC Motor Fundamentals

P. Finnie

Key Physical Principal at Play = *Lorentz Force* (*Any current-carrying conductor placed within an external magnetic field experiences a torque*)

Basic Components ->

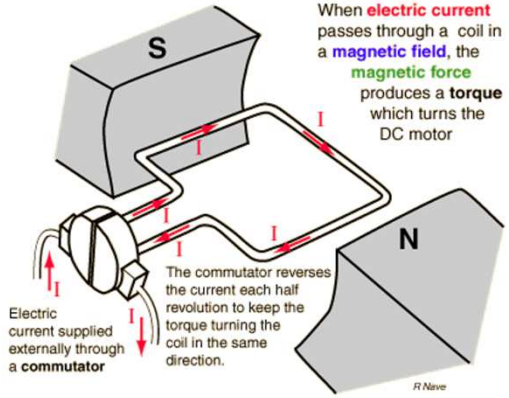
1. Stator
2. Rotor/Armature
3. Commutator
4. Brushes or Controller-(Brushless)



sigma.ontologyportal.org

Variants ->

1. Brushed (Mechanically Commutated)
2. Brushless (Controller Provides Commutation)
3. Homopolar (No commutation required)



hyperphysics.phy-astr.gsu.edu

Commutator – A commutator is a rotary electrical switch in that periodically reverses the direction of current between the rotor and the external circuit.

Credits:

http://en.wikipedia.org/wiki/DC_motor

Stepper Motors

J. Scot Collins

- Brushless, electric motor that converts pulses into mechanical shaft rotation.
- Utilizes an open loop control system, meaning there is no feedback as to motors position.
- Very accurate, within 3-5% normally.
- Micro-stepping is a way to vary current using a sine/cosine waveform to decrease vibration from jumping to new positions. Effectively increases number of steps.
- Ascending torque drive order – wave, half-step, micro-step, full step

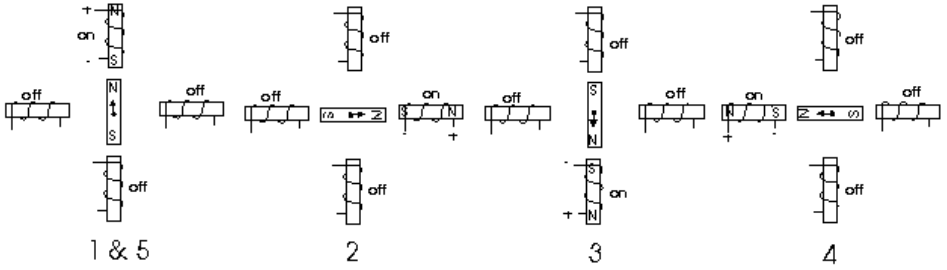


Figure 1: 90 degrees resolution (Wave drive, less torque)

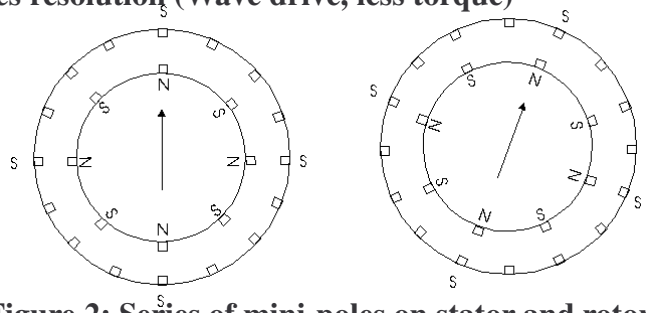


Figure 2: Series of mini-poles on stator and rotor.

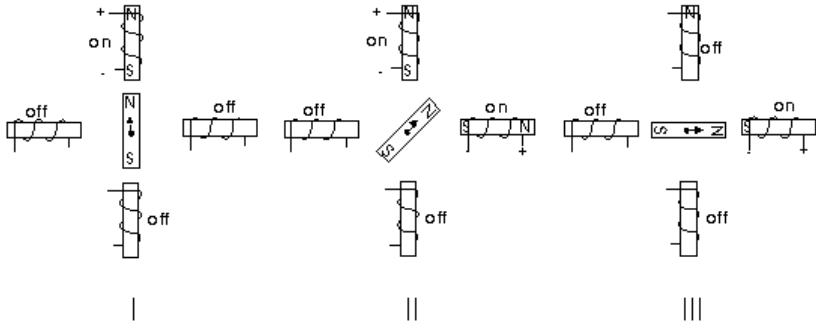


Figure 3: Half Stepping (doubles resolution, considerably less torque at half step position)

Images: http://www.imagesco.com/articles/picstepper/02.html#fig3
Information : http://www.imagesco.com/articles/picstepper/02.html#fig3
http://en.wikipedia.org/wiki/Stepper_motor

Servo Motors

- Motor with built in encoder
- Negative feedback for position and speed
- Outputs pulses that can be counted to find position and speed
- Applications:
  - Industrial robotics and automation
  - Autonomous robotics
  - Automotive
  - Machine Tools

References:
1. http://en.wikipedia.org/wiki/Servo_motor
2. http://www.baldor.com/products/servomotors/c_series/bsm_cseries.as

Traction Control

- Usable Traction = Coefficient of Traction x Weight

  where Coefficient of Traction is dependent on:

  - Material composition of each surface
  - Normal force pressing contact surfaces together
  - Contaminants at the material boundary including lubricants and adhesives.

- Mechanisms to obtain Traction Control

- Breaks

http://www.youtube.com/watch?v=Z1TP3NHtmJI&feature=youtu.be

- Control Engine Power

http://www.youtube.com/watch?v=28PO6QMzcsU

Propeller

-A type of fan that converts the rotational motion of the blades into thrust.

-Two main type of propellers are marine and aircraft.

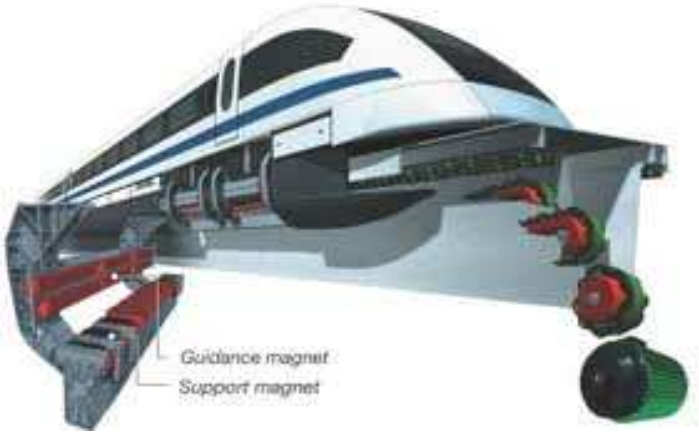
-Marine: Controllable pitch, skewback, and modular.

-Aircraft: Fixed pitch, in-fight adjustable, ground adjustable, and constant speed.

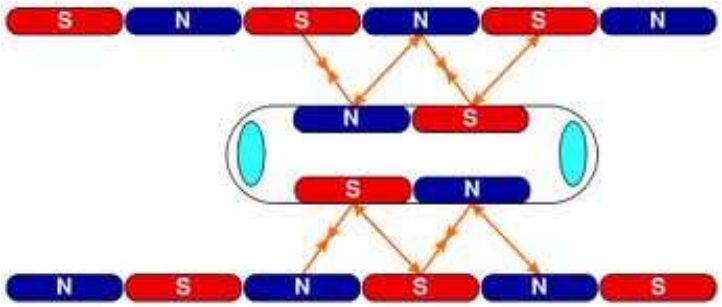
http://upload.wikimedia.org/wikipedia/commons/3/35/Ship-propeller.jpg

http://upload.wikimedia.org/wikipedia/commons/c/c3/Hercules.propeller.arp.jpg

MAGNETIC LEVITATION (MAGLEV)



Source: <http://www.theenterprisectr.org/high-speed-ground-transportation/maglev-technology.html >

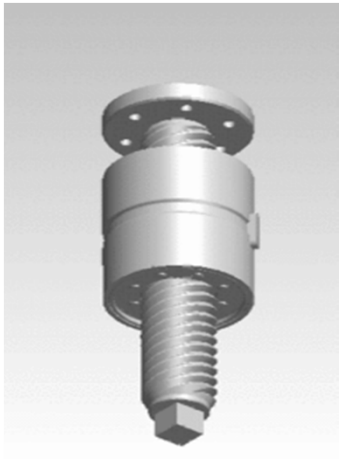


Source: <http://en.wikipedia.org/wiki/Maglev >

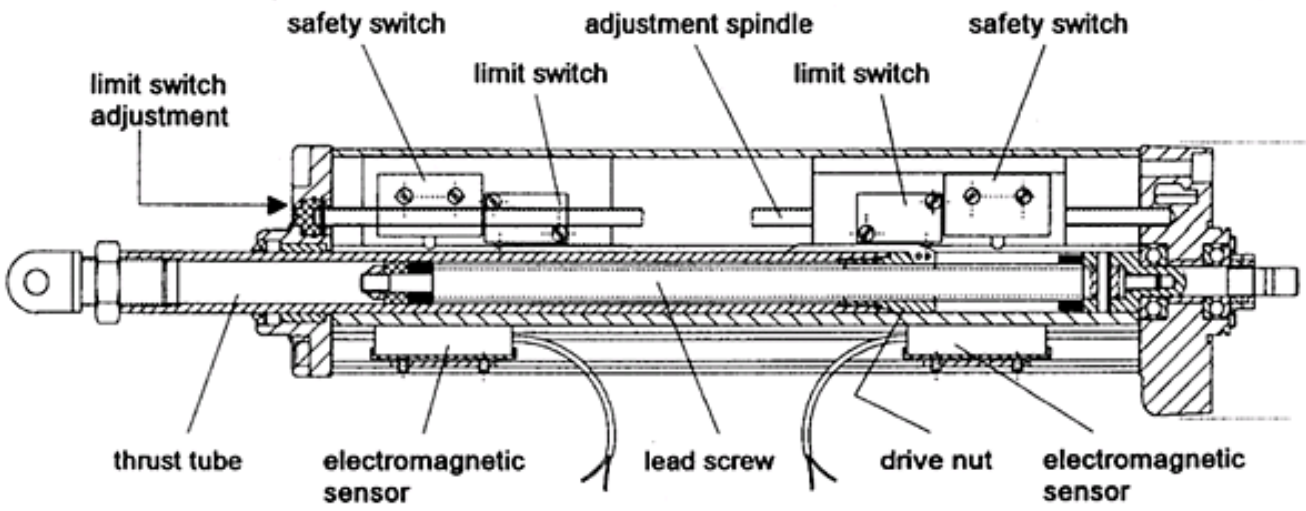
- Concept first thought of for transportation in early 1900's by Bachelet (France) & Goddard (U.S.)
- 2 Main types of MAGLEV
  - EMS (Attractive)
  - EDS (Repulsive)
- Most commonly used for trains today (Germany & Japan)
- Highest recorded speed of 361mph achieved by Japan in 2003
- Does not rely on wheels, axels, or bearings (essentially frictionless)
- Less maintenance required

Linear Motion - Screw

- Ø Screw actuator is a type of mechanical linear actuator that converts rotary motion into linear motion.
- Ø Different type of screw actuators are lead screw, screwjack, ball screw and roller screw.
- Ø Screw actuator can be mechanical (manual) or electro-mechanical (motor driven).



http://en.wikipedia.org/wiki/Lin
ator#Linear_motors

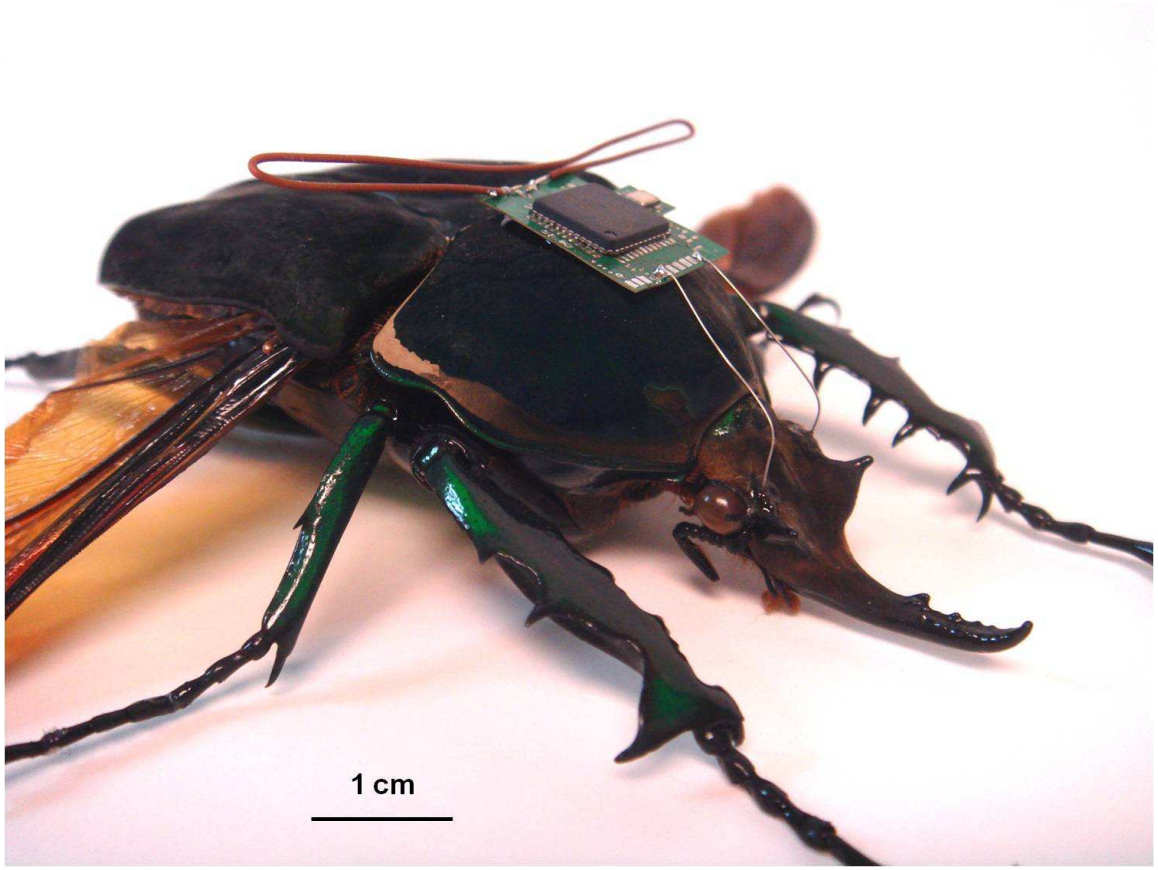


http://www.concisemotion.com/Flexline/Flex1-EZ.htm

Different Linear Actuator Types

Actuator Type	*Advantages*	*Disadvantages*
Mechanical	Cheap. Repeatable. No power source required. Self contained. Identical behaviour extending or retracting.	Manual operation only. No automation.
Electro-mechanical	Cheap. Repeatable. Operation can be automated. Self-contained. Identical behaviour extending or retracting. DC or stepping motors. Position feedback possible.	Many moving parts prone to wear.
Linear motor	Simple design. Minimum of moving parts. High speeds possible. Self-contained. Identical behaviour extending or retracting.	Low force.
Piezoelectric	Very small motions possible.	Requires position feedback to be repeatable. Short travel. Low speed. High voltages required. Expensive. Good in compression only, not in tension.
Hydraulic	Very high forces possible.	Can leak. Requires position feedback for repeatability. External hydraulic pump required. Some designs good in compression only.
Pneumatic	Strong, light, simple, fast.	Precise position control impossible except at full stops
Wax motor	Smooth operation.	Not as reliable as other methods.
Segmented spindle	Very compact. Range of motion greater than length of actuator.	Both linear and rotary motion.
Moving coil	Force, position and speed are controllable and repeatable. Capable of high speeds and precise positioning. Linear, rotary, and linear + rotary actions possible.	Requires position feedback to be repeatable.

MEMS - Microelectromechanical systems

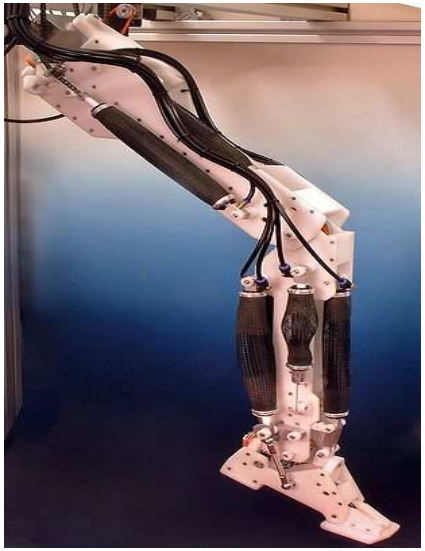


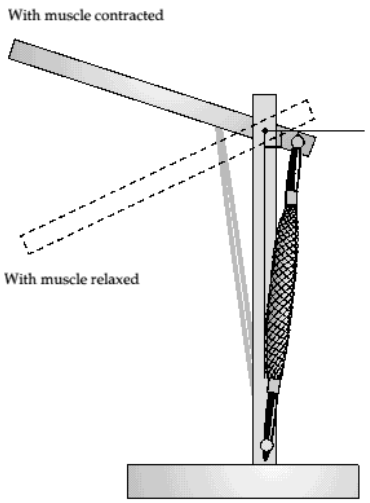
Size: 1 – 100 micrometers

Technology is still advancing.

Robotic Leg Power by Air

- **Actuators: Pneumatic artificial muscles (PAMs)**
  - Contracting and extending devices operated by pressurized air filling a pneumatic bladder
  - Light weight, easy to build, low cost, powerful, smooth, flexible
- **Degrees of freedom: 6**
- **Control System:**
  - Potentiometers for positioning feedback
  - Muscle Pressure monitored by air delivery system
- **Simulates the Normal Human walking speed**
- **It has the strength of 1kg load at the ankle**





http://www.davidbuckley.net/FR/ShadowLeg/ShadowLeg.htm#leginframe

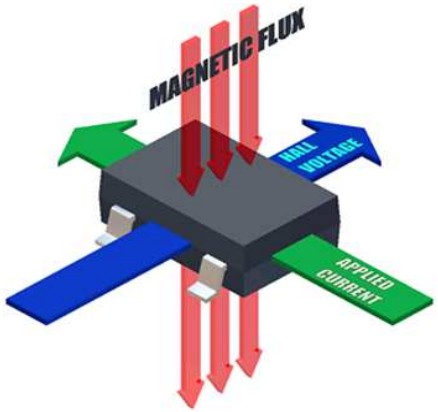
Made by Shadow Robot Co.

The Hall Effect

(a)

Who: Discovered by physicist Edwin Hall

What: The increase/decrease in voltage perpendicular to a path of current due to the presence of a magnetic field



(b)

When: Discovered in 1879

Where: Johns Hopkins University in Baltimore, Maryland.

Why: Originally used to classify chemical samples, but is now used in probes and transducers

How: http://www.magnet.fsu.edu/education/tutorials/java/halleffect/index.html

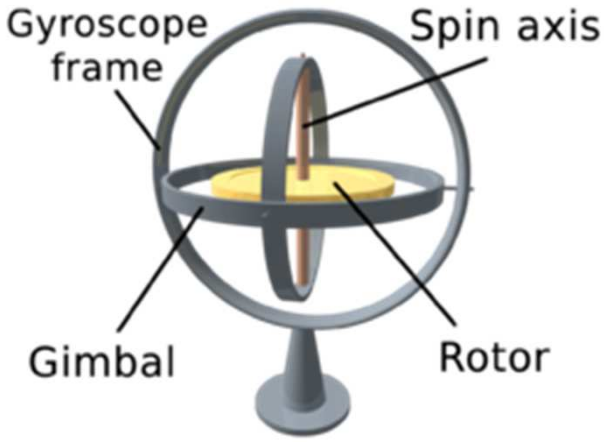
(a) http://www.magnet.fsu.edu/education/tutorials/java/halleffect/index.html

(b) http://www.ecnmag.com/articles/2009/03/sensor-zone-april-2009

(c) http://www.melexis.com/Assets/What-is-the-Hall-Effect-3720.aspx

Gyroscope Technology

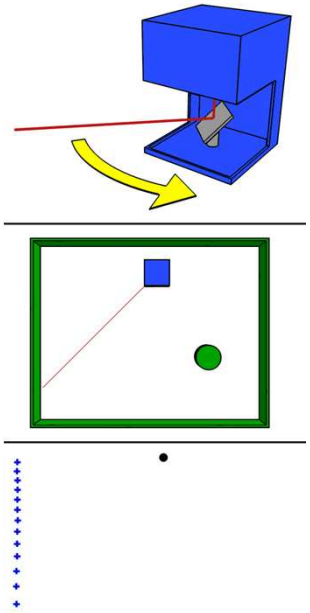
- A gyroscope is a device for measuring and/or maintaining the orientation of a device.
  - This is done with principles of angular momentum.
- There are multiple kinds of gyroscopes.
  - An easy form is a fast spinning mass that points in a fixed direction
- Uses can include compasses, computer pointing device, and more.
- An example of uses for gyroscopes: http://www.youtube.com/watch?v=BpYwgvLQRIM



http://en.wikipedia.org/wiki/File:3D_Gyroscope.png

LIDAR (Light Detection and Ranging)

- **LIDAR** is the use of electromagnetic waves within the 600nm-1000nm range to measure distance. LIDAR units are generally comprised of:
  - laser
  - optics
  - photo sensor
  - GPS/IMU
- Used in robotics as a way to map the environment and classify objects. LIDAR has applications such as:
  - generating topographical contour maps
  - threat detection
  - automated transportation
  - 3D point cloud



Basic LIDAR system [1]

Microsoft Kinect [3]

Police LIDAR [2]

Navy Fire Scout [4]

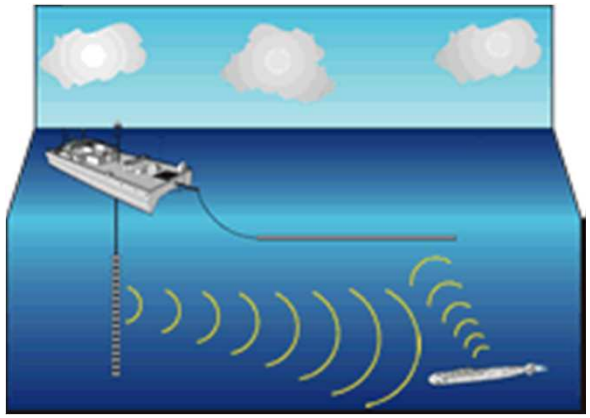
[1]http://en.wikipedia.org/wiki/LIDAR#Design
[2]http://www.stalkerradar.com/lidar_lr.shtml
[3]http://www.xbox.com/en-US/Xbox360?xr=shellnav
[4]http://www.naval-technology.com/projects/fire-scout-vtuav/fire-scout-vtuav6.html

SONAR

SOund **N**avigation **A**nd **R**adar

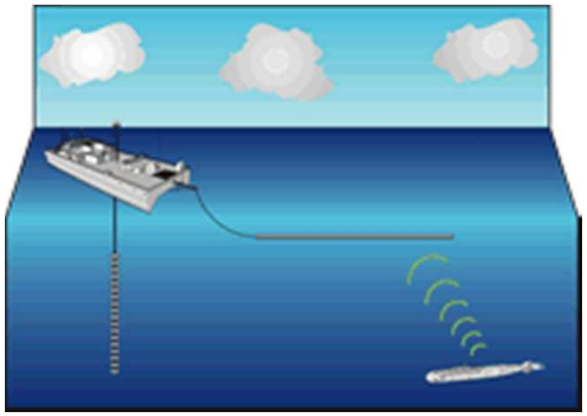
à uses sound propagation to navigate, communicate with, or detect objects

Active SONAR



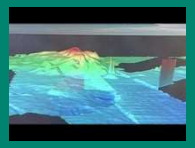
http://www.surtass-lfa-eis.com/Highlights/index.htm

Passive SONAR



APPLICATIONS

Warfare



Scientific

Civilian

http://www.naval-technology.com

http://www.blueview.com

http://www.fishfindersdirect.com/

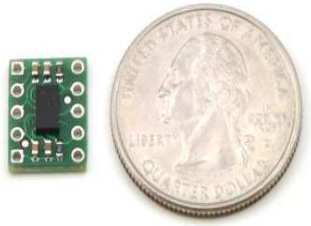
Accelerometers

Who invented it?

- First Accelerometer invented in 1783 by George Atwood
- Called the "Atwood Machine"

What do they look like?

- Accelerometers vary in package size and functionality


[4]

When do we use them?


[1]


[2]

Where can they be found?

- From around your waist to outer space!


[3]

[5]

Why do we need them?


[7]

How would we survive without them?

- No Planes, Trains, or Automobiles


[6]

References:
[1] (2011). *Mengenal Kecanggihan Teknologi Accelerometer iPhone*. (2011). [Web Photo]. Retrieved from http://portal.paseban.com/article/4088/accelerometer-iphone-
[2] (2009). *Wii therapy: Using the wii and wii fit in special education* . (2009). [Web Photo]. Retrieved from http://nolimitstolearning.blogspot.com/2009/02/wii-therapy-using-wii-and-wii-fit-in.html
[3] (2012). *New balance via slim pedometer*. (2012). [Web Photo]. Retrieved from http://www.campmor.com/balance-slim-pedometer.shtml
[4] (2012). *Mma7361l/mma7341l 3-axis accelerometer with us quarter for size reference.* . (2012). [Web Photo]. Retrieved from http://www.pololu.com/catalog/product/1247
[5] The appliance of rocket science? An accelerometer developed by Honeywell in the 1980s for use on the space shuttle. Photo by courtesy of NASA Johnson Space Center (NASA-JSC).
[6] (2012). *Planes, Trains, and Automobiles (and Boats): Transportation Industry Back on Track*. (2012). [Web Photo]. Retrieved from http://www.forbes.com/sites/sageworks/2011/07/05/planes-trains-and-automobiles-and-boats-transportation-industry-back-on-track
[7] (2012). *Below front airbags deployed*. (2012). [Web Photo]. Retrieved from http://www.dashwarninglights.co.uk/1199.html

Global Positioning System

- Space-based satellite navigation system
- Works in any weather
- Free to access
- Must be visible by four or more satellites
- Works by receiving signals from different satellites and timing each signal

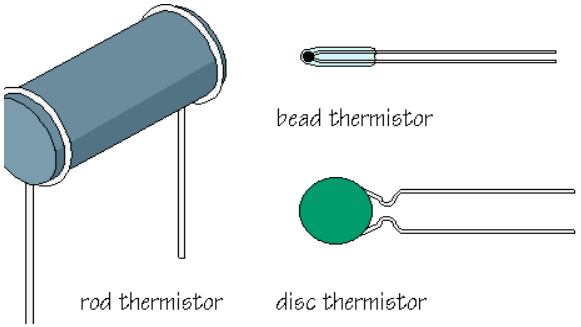
- Speed of satellite orbit is taken into account when calculating position of receiver
- User device never sends signals.

http://www.gpshacks.com/images/3627-GPS.jpg

http://web.archive.org/web/20061111202317/http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=154870&pageID=6

Temperature Sensor

Technology that serves the purpose of measuring the temperature (coolness or warmth) of an object or substance

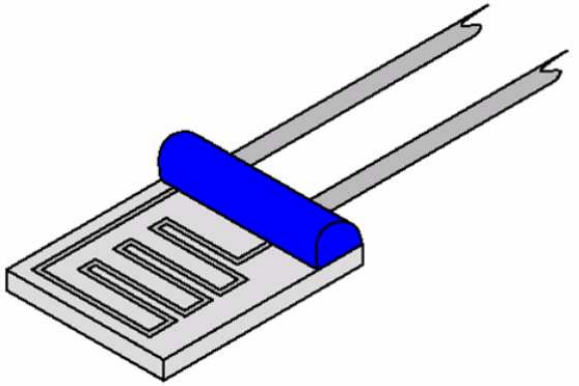


Thermistor

http://www.doctronics.co.uk/voltage.htm

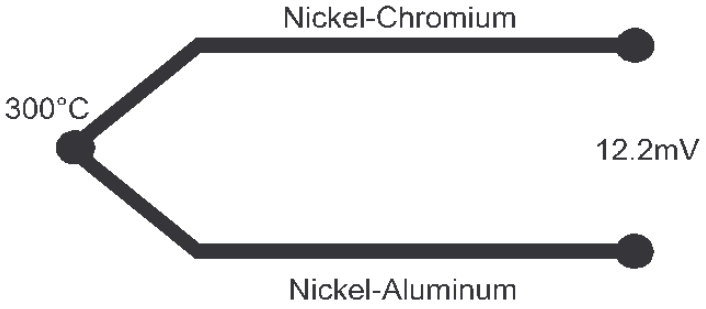
Thermometer

http://earth911.com/wp-content/uploads/2011/02/Thermometer.jpg?84cd58



Resistance Temp. Detector

http://en.wikipedia.org/wiki/File:Thin_Film_PRT.png

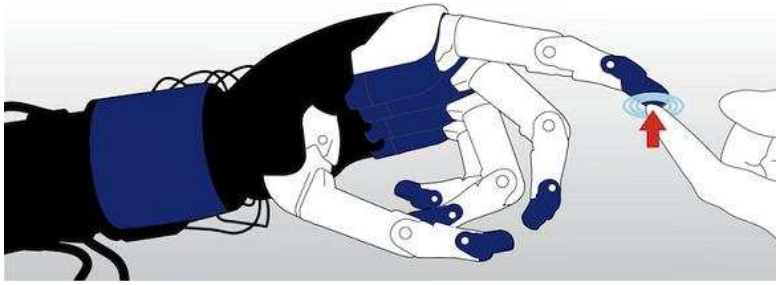


Thermocouple

http://www.picotech.com/applications/thermocouple.html

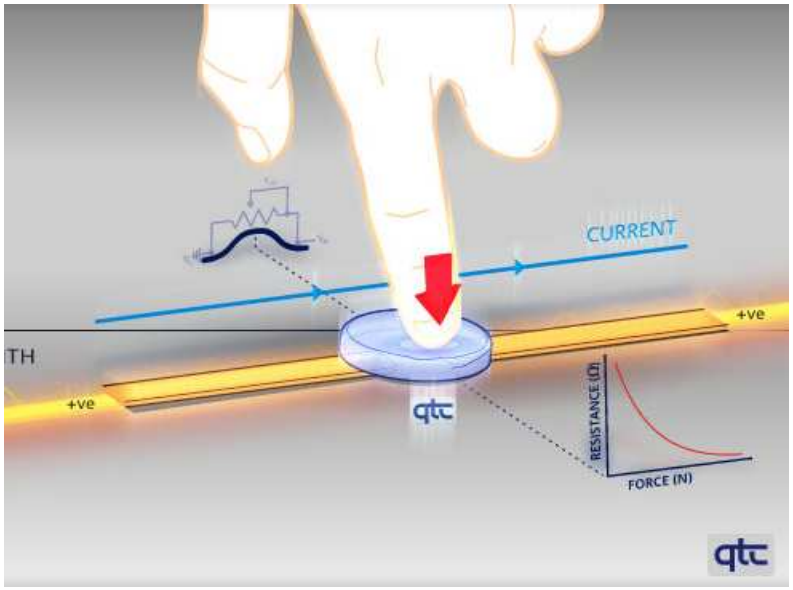
Quantum Tunneling Composite

- More accurate than resistive.
- Less power consumption than capacitive.
- Can provide 3 dimensions of interaction



2

Could let a robot know precisely where it has been touched, and with how much pressure.



1

Will be helpful in designing machines that have better grasping capabilities, and for developing more natural ways for machines to interact with humans.

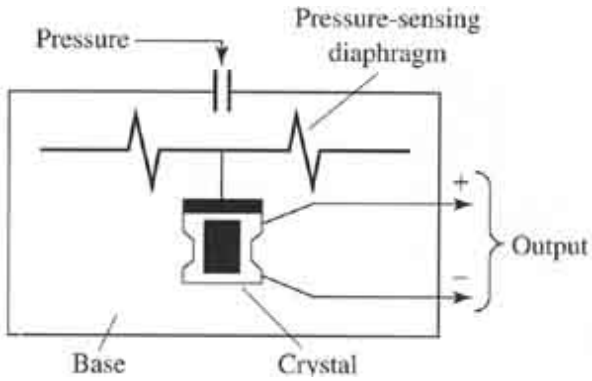
(1)- http://cache.io9.com/assets/images/4/2010/01/touchytouchy.png (2)- http://singularityhub.com/wp-content/uploads/2010/02/QTC-sense-of-touch.jpg

Pressure Sensing Technology

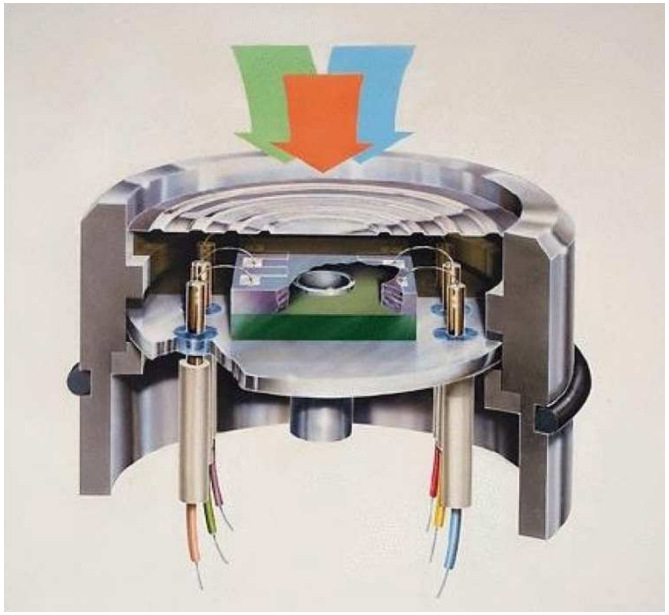
By Patterson C. Taylor III

- Absolute
- Vacuum
- Gauge

These typically take the form of a differential pressure sensor that implements some sort of displaced diaphragm to measure a pressure difference between two sources.

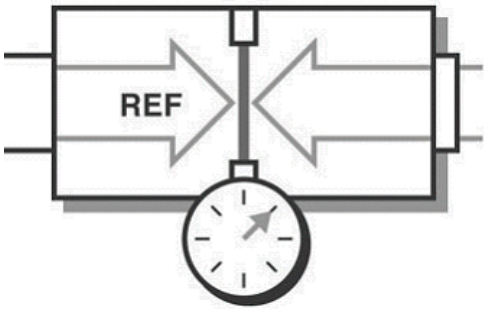


Source: http://www.data-acquisition.us/industrial_electronics/input_devices_sensors_transducers_transmitters_measurement/sensors/Piezoelectric-Pressure-Sensors.jpg



Source: http://www.emeraldinsight.com/fig/0870270304009.png

Piezoelectric strain gauges utilize a change in voltage or current caused by physical deformation.



Source: http://www.ni.com/cms/images/devzone/tut/a/a851fe69743.gif

Electromagnetic and Capacitive sensors operate in a similar fashion, where the displacement of a diaphragm is measured using a form of strain gauge.

Robotic Use of Cameras

Robots use cameras as sensors.

- Image recognition
- Depth sensing

Cameras have many applications in robotics.

- Response to human interaction
- Mapping an environment
- Navigation
- Response to images or objects

http://www.engadget.com/2010/06/13/microsoft-kinect-gets-official/

Example:

1. http://spectrum.ieee.org/automaton/robotics/diy/top-10-robotic-kinect-hacks

1. IEEE, "Top 10 Robotic Kinect Hacks", Evan Ackerman, 3/7/2011

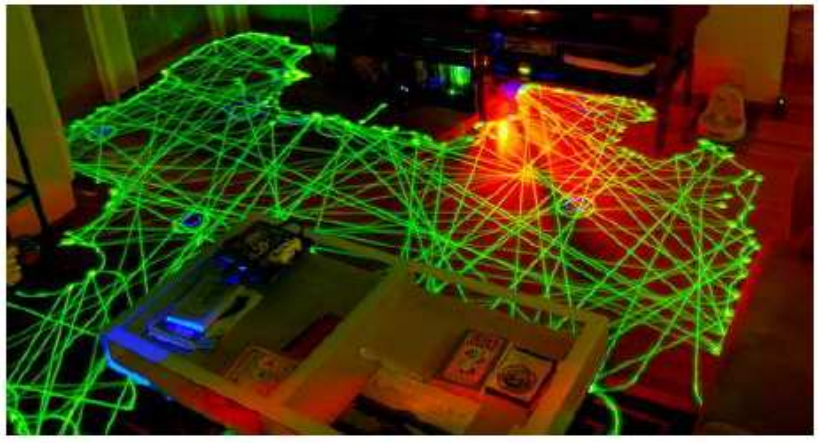
Locomotion

From our book:

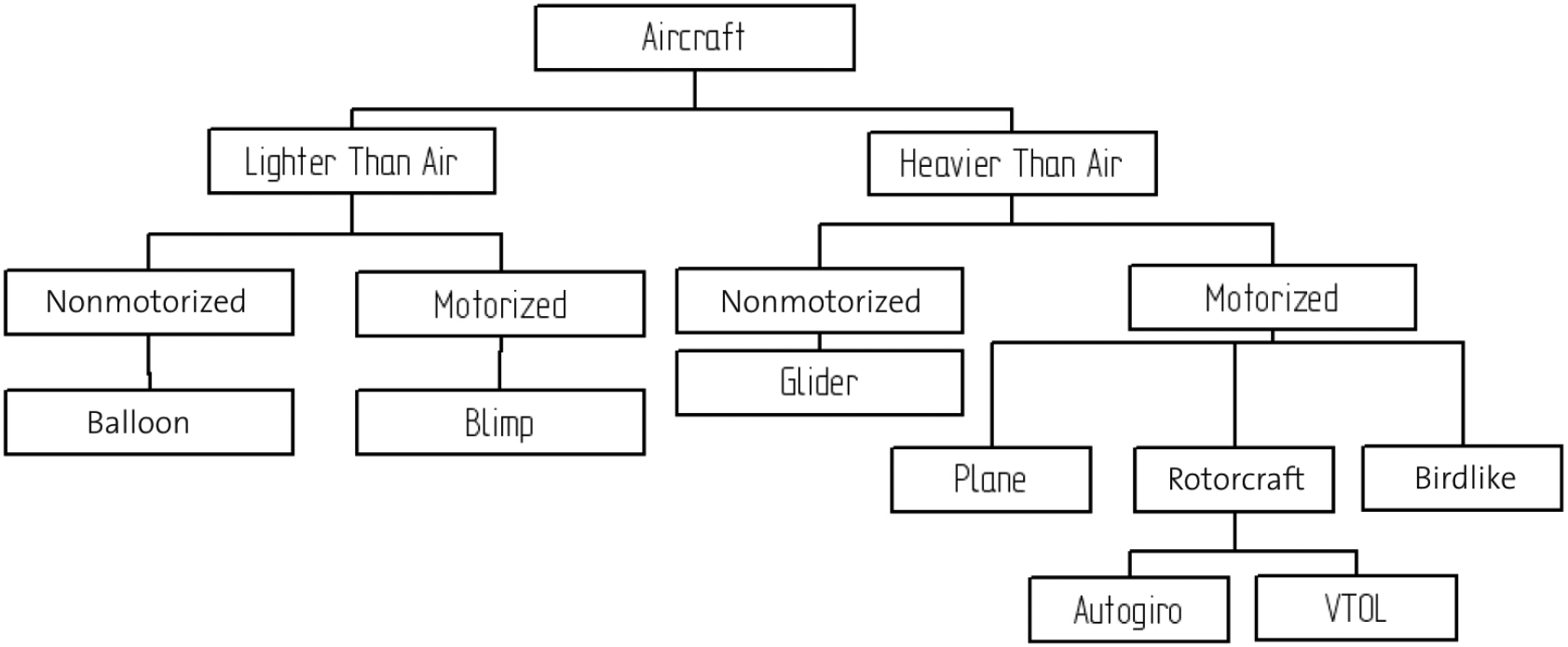
- Legs
- Wheels
- Aerial
- Missing is underwater, slithering, climbing, treads, others?

Wheeled Control – Case Study

- iRobot Roomba vs.
- Neato XV-11



Images courtesy http://www.botjunkie.com


Aircraft
Lighter Than Air
Heavier Than Air
Nonmotorized
Motorized
Nonmotorized
Motorized
Balloon
Blimp
Glider
Plane
Rotorcraft
Birdlike
Autogiro
VTOL