

# Signal layer Properties: Sensors and Effectors

At the lowest layer, the simplest processes that take place are sensors receiving signals from the environment, and motors that interact with the environment.

	<i>Signal</i>	<i>Information</i>	<i>Attribute</i>	<i>Simple Model</i>	<i>Abstract Model</i>	<i>Lifetime</i>
<i>Input Channel</i>	<i>Sensor</i>	<i>Binary</i>	<i>Detection</i>	<i>Maps</i>	<i>Logic</i>	<i>Agent Modeling</i>
<i>Output Channel</i>	<i>Motor</i>	<i>Kinematics</i>	<i>Action Selection</i>	<i>Path Planning</i>	<i>Task Planning</i>	<i>Goal Selection</i>

We begin with sensors.

## 1. Photoresistors, phototransistors, photodiodes

- (a) Components which vary behavior based on how much light is hitting them.
- (b) When much light is hitting it, it has low resistance. A typical range is 30K  $\Omega$  to 1M  $\Omega$ , but they can go as low as 100  $\Omega$  and as high as 50M  $\Omega$ .
- (c) How do they work? To quote Pushpinder Singh, "Its a quantum thing". Its a property of the cadmium sulphide.
- (d) Can be used to cause a mobile robot to react to light.
- (e) Phototransistors and photodiodes have similar sorts of properties.

## 2. Microswitches

- (a) Yes, that's right, small switches.
- (b) Useful for touch sensors.

## 3. Microphone

- (a) Obvious what its used for.
- (b) Sound is waves of variation in air pressure.
- (c) Microphones pick this up through the vibration of a diaphragm.
- (d) This is converted to an electrical signal in many ways. The simplest is that the vibrating diaphragm is connected to a coil of wire, which also shakes. The wire is in a magnetic field, which generates current. The voltage of that current fluctuates along with the pressure of the air.

#### 4. Infra-red proximity detectors.

- (a) Signal whether or not something is in the "cone of detection".
- (b) Emits an infra-red beam, waits for reflection. (Uses infra red very close to light in wavelength, so heat does not interfere. Much. Florescent lighting on the other hand, does).
- (c) In the basic model, emitter oscilates at 40kHz, and if IR reflection is deteted, assume an object is in that direction.
- (d) Detection is done with a photodiode.
- (e) How do we account for distance?
  - i. Time of flight. Potential problem: short times.
  - ii. Vary power.

#### 5. Sonar

- (a) Like infra-red, but better at a distance.
- (b) Send out a ping at 50 KHz. (Average human hearing tops out at 20 KHz. At age 20, its up around 25 KHz.)
- (c) Signal moves out at speed of sound (Much lower than light: 343.2 m/s, spreading out so that energy drops  $\frac{1}{d^2}$ , limiting range to 35 feet or so.
- (d) Sound is reflected back, and a microphone (transducer) picks it up, measuring time of flight.
- (e) Because the microphone could pick up the ping, it is turned off during and right after the ping.
- (f) This creates a minimum range of about 2 feet.

#### 6. Lasers

- (a) Because regular IR and sound all spread out in cones, they become less accurate with distance. Its nearly impossible to get shape.
- (b) Lasers don't spead out in a cone (that the point) so they don't have this problem. Instead they emit a 1-3 mm wide beam.
- (c) They otherwise work the same as IR and sonar: emit, detect reflection, measure time of flight.
- (d) The beams can go much longer distances (50 m), and are much more accruate over the entire range of the sensor.
- (e) Often arranged in a *fan* of lasers to sense a wider area. These can be as close as every 0.72 or a degree. This can be done with a single moving laser gun instead.
- (f) This still only measures a single plane, but with multiple units or by constantly moving the unit, a detailed distance image of the external world can be built.

#### 7. Shaft encoders.

- (a) We'll have motors that move our robot. Most of these motors revolve something. Even if the eventual motion is linear, this is usually converted from the rotational movement of the motor.
  - (b) It would be useful to know how far our motors have turned. Theoretically, would could keep track of how much we told the motor to turn, but that is tricky in practice. Instead we can measure it with shaft encoders.
  - (c) The simplest way this is done is to pass the shaft through the center of a disc. The disc is striped, white and black. An infra-red beam is reflected off the disc. The black stripes absorb the beam, and the white ones reflect it. The IR receiver counts the flashes to determine how far the shaft has turned.
8. Gyros
  9. Mercury Tilt Sensors
  10. Electrolytic inclinometer
  11. Flux Gate Compass
  12. GPS
  13. Cameras
    - (a) Digital cameras, both still and video use a charge coupled device (CCD) to gather an image. A CCD is an array of diodes that are light sensitive: when a photon hits them, they build up a charge.
    - (b) As a photon enters the camera it hits (at least in a good camera) a beam splitter. A beam splitter is something that reflect some of the light in one direction and lets the rest pass through, such as a prism or a partially silvered piece of glass.
    - (c) Once the light is broken into three beams, each beam is passed through a colored filter, either red, green or blue, so that only photons of that type pass through.
    - (d) Each colored beam hits its own array of diodes, which build up charge that is fed into the processor as a image of that color light.
    - (e) These are usually converted into bits in the information layer, where they can be re-assembled into an image.

Now, for the effectors. Effectors are the things a robot uses to change the environment. Technically, any LCD or similar screen is an effector. A speaker is also an effector. Most effectors are motors.

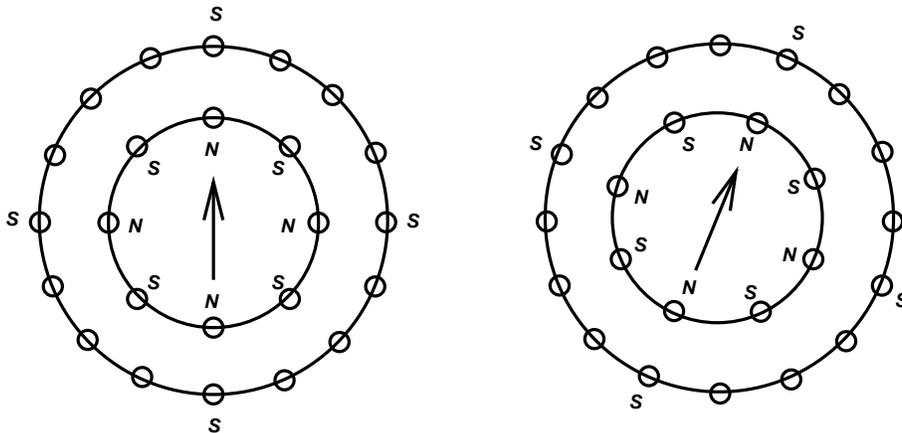
1. Electric motors turn electricity into motion. Most are of two basic types: DC brush motors, and brushless stepper motors.
2. All motors have the thing that rotates, the rotor, and the thing that's stationary, the stator.

### 3. DC motors

- (a) The stator is made up of two (or possibly more) magnets, with opposite polarity.
- (b) The rotor is wrapped in a coil of wire, connected to the electric input by brushes. When the current is on, a magnetic field is created. The rotor turns to orient the field with respect to the magnets.
- (c) As it turns, the brushes lose contact with the contacts on the rotor, but new contacts swing into place. These new contacts route the current in the opposite direction, so that the polarity of the magnetic field switches, causing the rotor to keep turning to re-orient itself with the magnets.
- (d) To prevent the rotor from getting stuck in the middle, it usually has 3 poles instead of just 2.
- (e) These motors have problems:
- (f) The brushes wear out.
- (g) Because the brushes are making/breaking connections, you get sparking and electrical noise.
- (h) Friction on the brushes limit the maximum speed of the motor.
- (i) Having the electromagnet in the center of the motor makes it harder to cool.

### 4. Stepper motors

- (a) Stepper motors flip the DC motor inside out. The fixed magnets go on the rotor, and the electro-magnets go on the stator. Because the electro-magnets aren't moving, no brushes necessary.
- (b) What we do instead is turn on and off the electro-magnets in the right order so that rotor will continue to spin.
- (c) Aside from **not** having the disadvantages of brushed motors, another big advantage is that we can include many more electro-magnets for finer control. See this image ripped off from <http://www.imagesco.com/articles/picstepper/02.html>



### 5. Movement (arms, hands, etc.)

(a) rotational and translational joints.

## 6. Locomotion

(a) We'll focus on wheeled, but there are walkers, flyers, etc.

(b) Synchro drive. Three wheels, each rotate in place to point in the right direction. The robot has no "front". Complex to build.

(c) Tricycle drive, Ackerman steering. One or two wheels in the front turn, like a tricycle or car. Large turn radius. Parking problems. (non-holonomic)

(d) Differential drive. Difference in wheel speeds results in turns. Nimble, but hard to drive in a straight line.

(e) Articulated drive. Robot has front and rear part. Motor rotates front around a pivot to swing wheels into line. Problems similar to car steering.