Wireless Sensor Networks

EP2980
Jonas.Wahslen@sth.kth.se

Sensors

- What to sense?
- How to sense/measure?
- Available sensors
  - Technology
- Medical
  - ECG
  - Pulsoximeter

Applications

- Smart Grid
- Industrial Automation
- Smart Cities and Urban Networks
- Home Automation
- Building Automation
- Structural Health Monitoring
- Body Sensor Networking
  - Health: monitor & assist disabled
  - Military: command, control, communications and computing.

Sensing

- As this course is named mobile services, we need to convert any *physical* value to an *electrical* value
- **From:** temperature, humidity, light, ... (none electrical)
- **To:** current, voltage, resistance, time interval or frequency

Property

- **Input range**: the operating range to which the sensor is sensing
  - E.g. Temperature sensor operating reliably from -5°C to 40°C.
  - Outside this range the sensor's fault tolerance is exceeded.
- **Output range**: range of the output value
  - E.g. Temperature sensor returns voltage between 0 and 5V

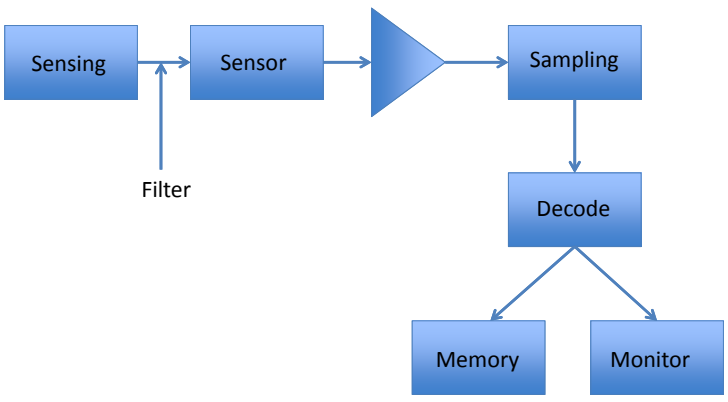
Property

- **Sensitivity**: How is a change in input signal mapped to the output signal?
  - E.g. an inclination sensor produces in output voltage of 1mv for every 2.30°.
- **Latency**: Speed with which sensor reacts to change
  - E.g. A temperature sensor having a latency of 14s per 10°C

Property

- **Stability**: insensitivity to factors other then measured physical quantity.
  - Noise: undesired change from ideal output value. E.g. thermal noise in the
  - Distortions. E.g. radioactive radiation influencing the sensor.
  - Environmental influences. E.g. temperature, air pressure, …

Sensor



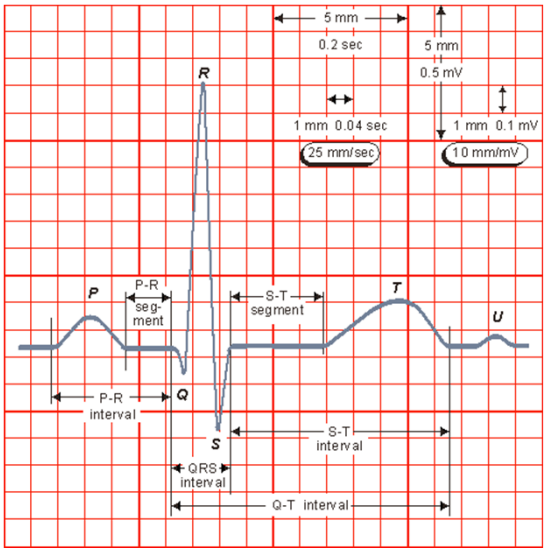
Sampling rate

- Nyquist theorem
  - The sampling rate has to be at least twice as fast as the fastest **change**. If not, you are going to miss relevant information.
  - E.g. If sound signal changes at 3 kHz, you have to sample at at least 6 kHz to not miss anything of the signal.

Bit depth

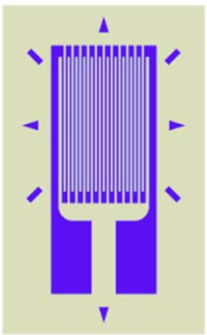
- An 8-bit sampling (quantization) gives an resolution of 256 levels.
- If a signal varies from 0 to 10V, using a 8 bit resolution. Given the sampling value of 3.1415.... V after coding 3.1372 V
  - 10/255 = 0.0392 V/level
  - 80*0.0392 = 3.1372 V

A normal electrocardiogram



Sensor technologies

- Contact sensor
- Force sensors
- Light sensing
- Gyroscope
- Accelerometers



Light sensors

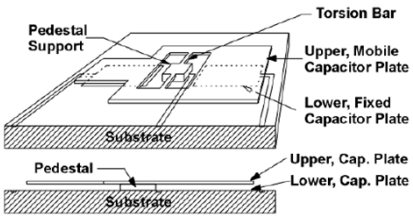
- Photo diode
  - Diode embedded in translucent plastic package
  - Conductivity influenced by photons hitting the n-p junction
- Photo transistors
  - Transistors embedded in translucent plastic package
  - Transistors amplifies (100 to 1000 times), can be hooked to a AD converter
- Light dependent resistors (LDR)
  - Resistance decrease when light falls on it
  - Not sensitive to infrared light
- Light to frequency converter
  - Diode combined with a IC to convert current to pulse
  - Accurate, light intensity on one wire

Other sensors

- Proximity sensors
  - Mechanical: contact sensor
  - Optical: consists of a light source (LED) and light detector (phototransistor)
- Potentiometer – displacement
- Linear variable differential transformer (LVDT) – movement
- Capacitance sensor, dependent on distance between the electrodes
- Piezoelectric sensors generates electrical potential when stressed

Accelerometers and gyro

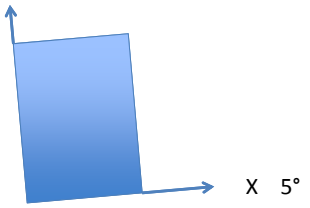
- Spring-mounted mass
- Newton's law and spring-mass relation



- Simplest micro electro-mechanical system (MEMS) device possible
- The widespread use of accelerometers have pushed the cost down dramatically

Exam question

Estimate the speed in the direction of the accelerometer's x-axis 5 seconds after the measurement started, which is the error due to incorrect mounting.

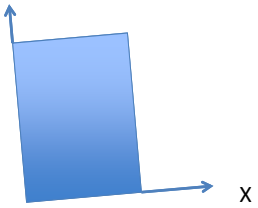


Exam question

Estimate the speed in the direction of the accelerometer's x-axis 5 seconds after the measurement started, which is the error due to incorrect mounting.

Speed = time * acceleration

5 * 9.81 * sin(5) = 4.27m/s



Analyze of acceleration

- Low-pass filer
  - Isolate constant acceleration
  - Used to find the device orientation
- High-pass filter
  - Show instantaneous moves only
  - Used to identify user-initial moves

Filter

- Engineering function for Low-pass filter
  - FilterFactor Ff= 0,1
  - FilteredValue Fv(n) = (SampledData * Ff) + (Fv(n-1) * (1,0 – Ff))
- High-pass filter
  - FilterFactor Ff = 0,9

Medical analyze

- Diagnose
  - Ocular
  - Audible
- Tele metric
  - Electrical
  - Chemical
- Information about
  - Skin
  - Heart
  - Lungs

Coff
Blood
Skin

What to sense

- Mechanical quantity (force, displacement)
- Pressure, flow, volume
- Thermic sensors
- Ultrasound
- Electrodes for bio potential
- Chemical sensors
- Optical sensors

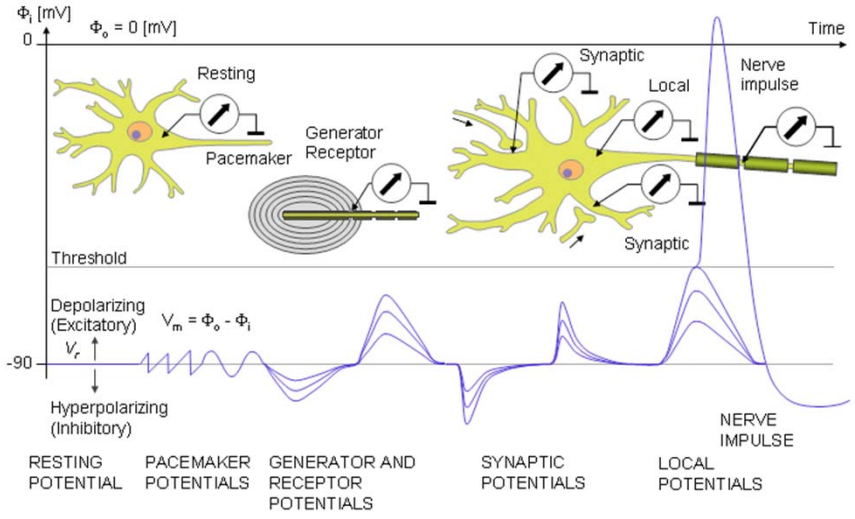
Medical values

- Example on things to measure on humans
  - Mechanical – muscle, bone mass
  - Thermic – infection, metabolism
  - Electrical – muscle, nerves
  - Chemical – blood gases, blood glucose, enzymes

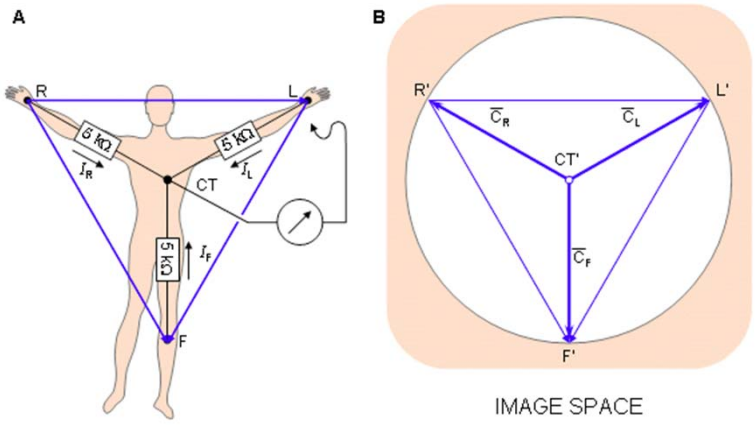
Medical sensors

- ECG
  - (Electrocardiogram)
  - Monitor the heart
- Pulse oximeter
  - Pulse and oxygen level
  - surveillance
- Pressure measurement
  - Blood pressure
  - Lung capacity
- Accelerometer
  - Stroke, alzheimers

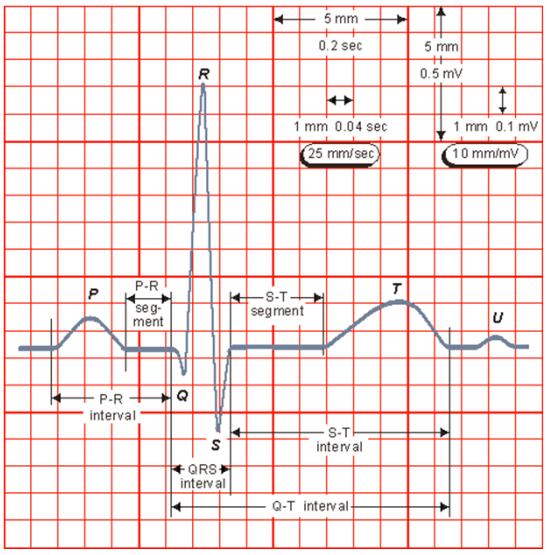
Bioelectric function of the nerve cell



The Wilson central terminal (CT)



A normal electrocardiogram

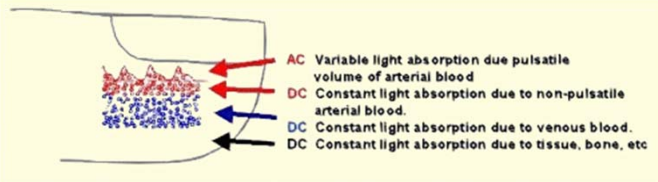


Pulse oximetry

- A non-invasive method to monitor oxygenation of a patient's hemoglobin
- That is fast
  - under 90% = new red blood cells are created
  - under 70% = increase risk of heartarytmier
  - under 30% = risk for life

Pulse oximetry

- Clinical use
  - Lung diseases
  - Operation (anestesi, surveillance)
  - Neonatal care
  - Surveillance in ambulance



Pulse oximetry

- Pulse oximetry – Two LED with wavelength 660nm and 910nm
- Two different absorption for Hb and $Hb0_2$
- Built on reference values