Wireless Networking
CS4222/5422

Tutorial 3

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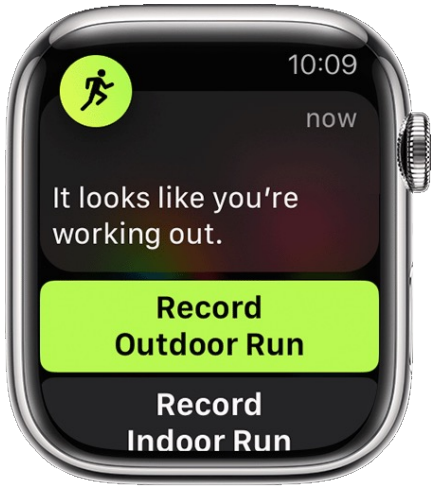
Q1

What sensors does your phone or wearable device (such as a Fitbit) use to estimate the number of steps you have taken? How does it perform step-counting?

Sensors used to estimate the number of steps you taken? How does it perform step-counting

- **Accelerometers**
  - MEMS(Microelectromachanical Systems) inertial sensors
- Often, an IMU (accelerometer + gyroscope) can also be used for this purpose. Modern devices often utilize a combination of sensors to accurately estimate the number of steps taken.
- Step counting inloves Machine Learning/Statistics based models to make sense of sensor data
  - frequency and intensity of the motion differs between activity
  - type of motion inferred to determine if it corresponds to a step.



*Credit: Google Images

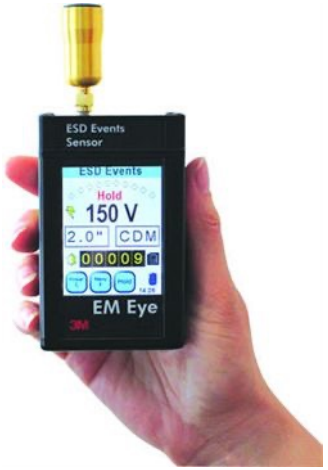
Q2

Please list the sensor(s) you plan to use to support the following application scenarios:

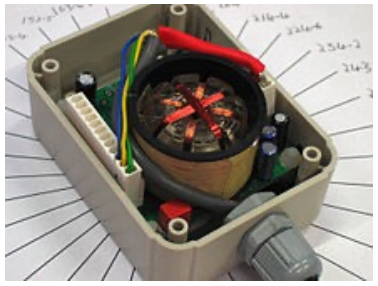
I. Detecting metallic objects that are buried in the soil
II. Detecting blood oxygen levels on a wearable device
III. Determining water level in a tank situated on top of a building
IV. Generate a 3D mapping of historical structures

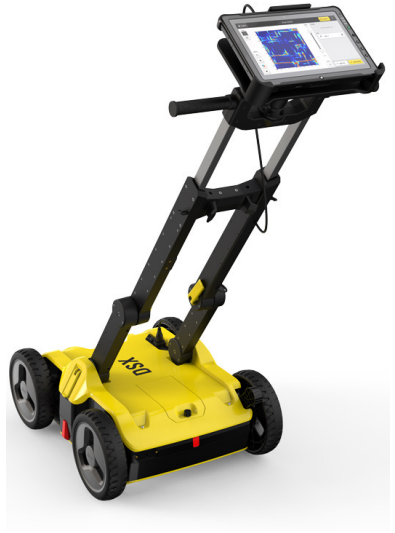
Which sensor to use?

I. **Detecting metallic objects that are buried in the soil**
   - Metallic objects cause change in physical property of soil. Need to detect the change
   - Magnetic Properties
     - Magnetometer - Measure strength and direction of magnetic field
     - Electromagnetic Induction Sensors – Use EM waves
   - Electrical Conductivity
     - Ground penetrating Radar (GPR) - Create image of subsurface using Radar waves



II. Detecting blood oxygen levels on a wearable device
III. Determining water level in a tank situated on top of a building
IV. Generate a 3D mapping of historical structures





*Credit: Google Images

Which sensor to use?

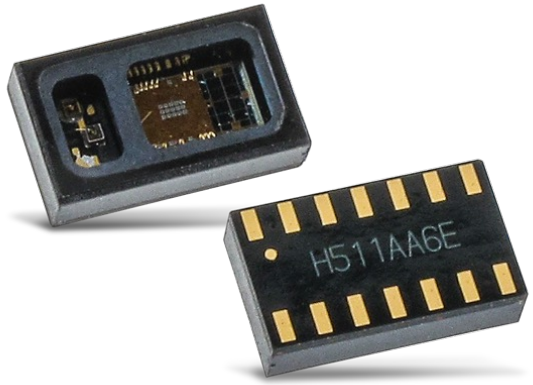
I. Detecting metallic objects that are buried in the soil

II. Detecting blood oxygen levels on a wearable device

- Pulse Oximeter
  - Absorption of light at different wavelengths, helps determine the oxygen saturation level
  - Light emitter shines red and IR light into blood vessels
  - Photodetector measures amount of light absorbed by blood

III. Determining water level in a tank situated on top of a building

IV. Generate a 3D mapping of historical structures



*Credit: Google Images

Which sensor to use?

I. Detecting metallic objects that are buried in the soil
II. Detecting blood oxygen levels on a wearable device
III. Determining water level in a tank situated on top of a building
    - Ultrasonic Sensors
        - High frequency sound waves to measure distance b/w sensor and water surface
    - Optical Sensors (IR/laser)
        - Detect amount of light reflected by water surface, using a light source and photodetector
IV. Generate a 3D mapping of historical structures

Which sensor to use?

I. Detecting metallic objects that are buried in the soil
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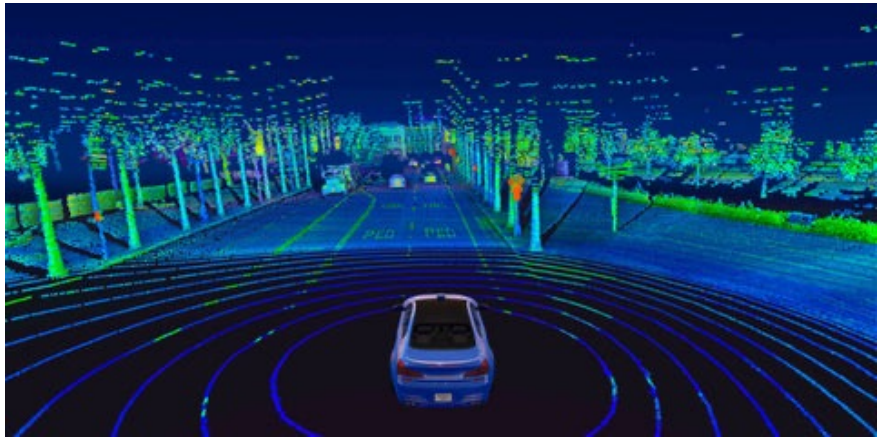
    - LIDAR(Light detection and Ranging) sensor



*Credit: Google Images

Q3

Molex produces thin-film/flexible batteries rated capacity of 10 mAH and voltage 3V.

a) Can you calculate the battery life when powering the following components of IoT devices exclusively (no other components are being powered)?
   - BME 280: Pressure, Humidity, Temperature Sensor (Sampling at 1Hz), current 3.6 microamperes
   - ADXL 337: Accelerometer, supply current 300 microamperes
   - OPT 101: Light sensor, current 120 microamperes
   - HM01B01: Camera, current approx. 1500 microamperes

b) How can you extend the battery life to a much longer duration than what was calculated in Part 3(a)? How do the characteristics of the application assist in making this decision?

Battery Life

- Power = V x A OR Wh = Ah x V
- $Battery\ Life = \frac{Battery\ Capacity\ (Ah)}{Load\ Current\ (A)}$

- BME 280 Lifespan $= \frac{Battery\ Capacity\ (Ah)}{Load\ Current\ (A)} = \frac{10\times10^{-3}}{3.6\times10^{-6}} = \frac{10\times10^{3}}{3.6} = 2777.78$ hours
- ADXL 337 Lifespan $= \frac{10\times10^{-3}}{300\times10^{-6}} = \frac{10\times10^{3}}{300} = 33.33$ hours
- OPT 101 Lifespan $= \frac{10\times10^{-3}}{120\times10^{-6}} = \frac{10\times10^{3}}{120} = 83.33$ hours
- HM01B01 Lifespan $= \frac{10\times10^{-3}}{1500\times10^{-6}} = \frac{10\times10^{3}}{1500} = 6.67$ hours

Extend Battery Life?

- For our calculations, we assumed the sensor is active at all times.
- We do not need to continuously sample the sensor data.
- For instance,
  - we may only need to take an image from the camera every minute.
  - Ambient temperature values might not change frequently, and therefore, sampling every hour could be sufficient
- Reducing active duration can result in a significant improvement in battery life

Thank you

Feel free to contact me at kanav.Sabharwal@u.nus.edu for any clarifications