SENSORS ON MOBILE DEVICES

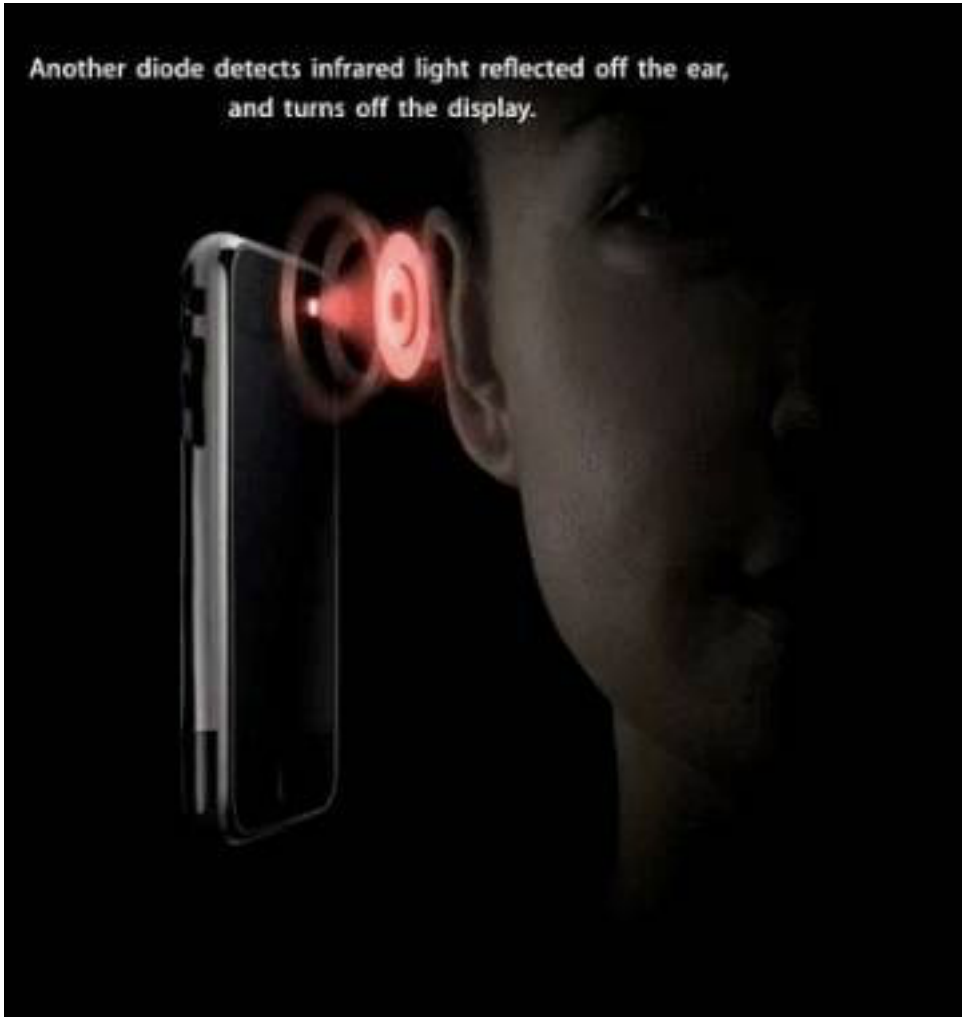
BLM5134 - Week 5

Sensor Types

- Acceleration/Vibration
- Acoustic/Ultrasonic
- Chemical/Gas
- Electric/Magnetic
- Flow
- Force/Load/Torque/Strain
- Humidity/Moisture Leak/Level
- Machine Vision
- Optical
- Motion/Velocity/Displacement
- Position/Presence/Proximity
- Pressure
- Temperature

Proximity Sensor

- A proximity sensor is a *sensor able to detect the presence of nearby objects without any is comprised of an infrared LED and an IR light detector.*
- *It is placed near the earpiece of a phone, and for a good reason. The sensor works by shining a beam of invisible to humans infrared light which is reflected from a nearby object and picked up by the IR detector.*



Light Sensor

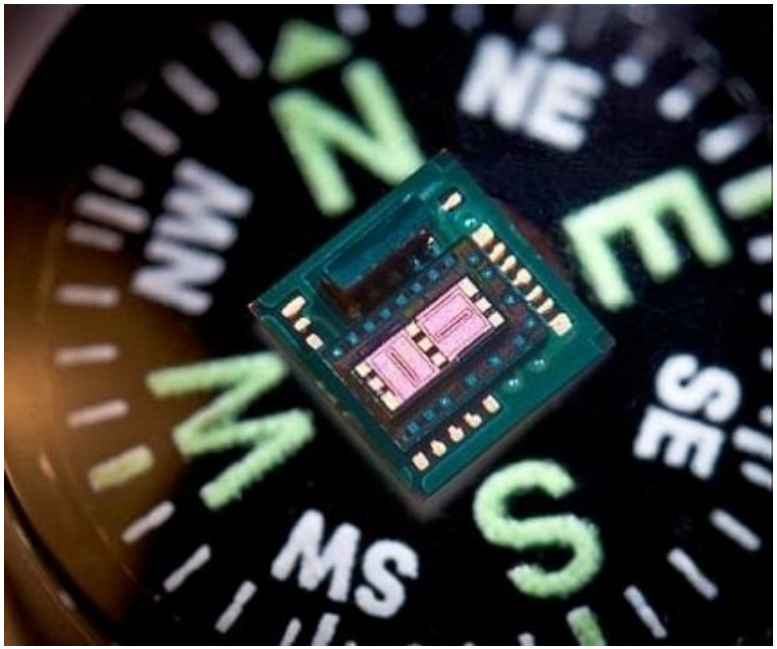
- A phone's light sensor is what measures how bright the ambient light is. The phone's software uses this data to adjust the display's brightness automatically – when ambient light is plentiful, the screen's brightness is pumped up, and when it is dark, the display is dimmed down.
- An interesting fact is that high-end Samsung Galaxy phones use an advanced light sensor that can measure white, red, green, and blue light independently.

Barometer

- Higher-end phones have a built-in barometer – a sensor that can measure atmospheric pressure. Data measured by it is used to determine how high the device is above sea level, which in turn results in improved GPS accuracy.

Magnetometer

- The digital compass that's usually based on a sensor called magnetometer provides mobile phones with a simple orientation in relation to the Earth's magnetic field. As a result, your phone always knows which way is North so it can auto rotate your digital maps depending on your physical orientation.



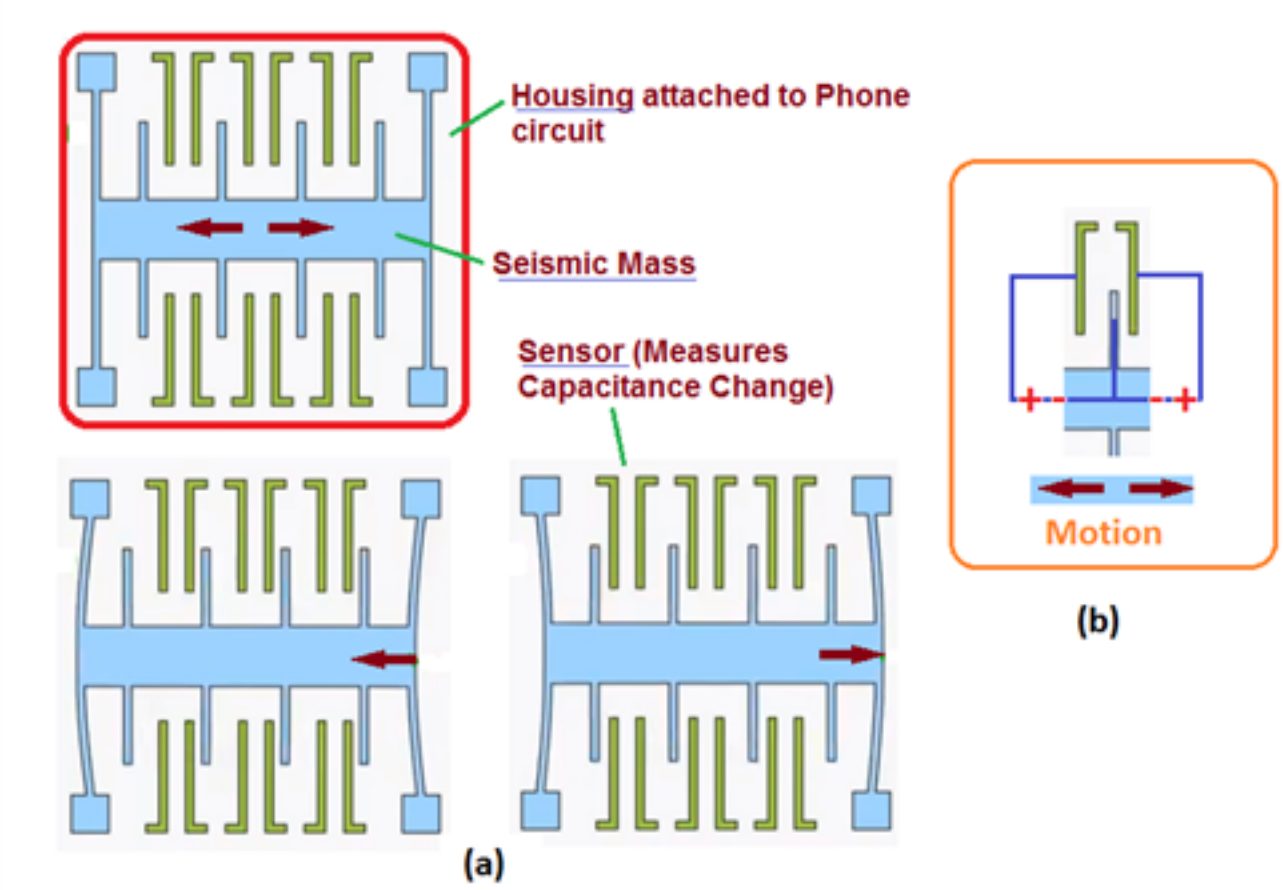
Accelerometer

- Accelerometers (Gravity Sensors) are devices that can measure acceleration (the rate of change in velocity), but in smartphones, they're able to detect changes in orientation and tell the screen to rotate. Basically, it helps the phone know up from down.

- All accelerometers have two fundamental parts:
- 1. A housing attachment to the object whose acceleration we want to measure.
- 2. A mass that, while tethered to the housing, can still move.

- For example assume a spring and a heavy ball. If you move the housing up, the ball lags behind stretching the spring. If we measure how much that spring stretches, we can calculate the force of gravity.

Accelerometer



Gyroscope

- The gyroscope is a sensor that can provide orientation information as well, but with greater precision. Thanks to this particular sensor, Android's Photo Sphere camera feature can tell how much a phone has been rotated and in which direction.
- It is also used by Google's Sky Map for telling what constellation you're pointing a phone at.

Thermometer & Hygrometer

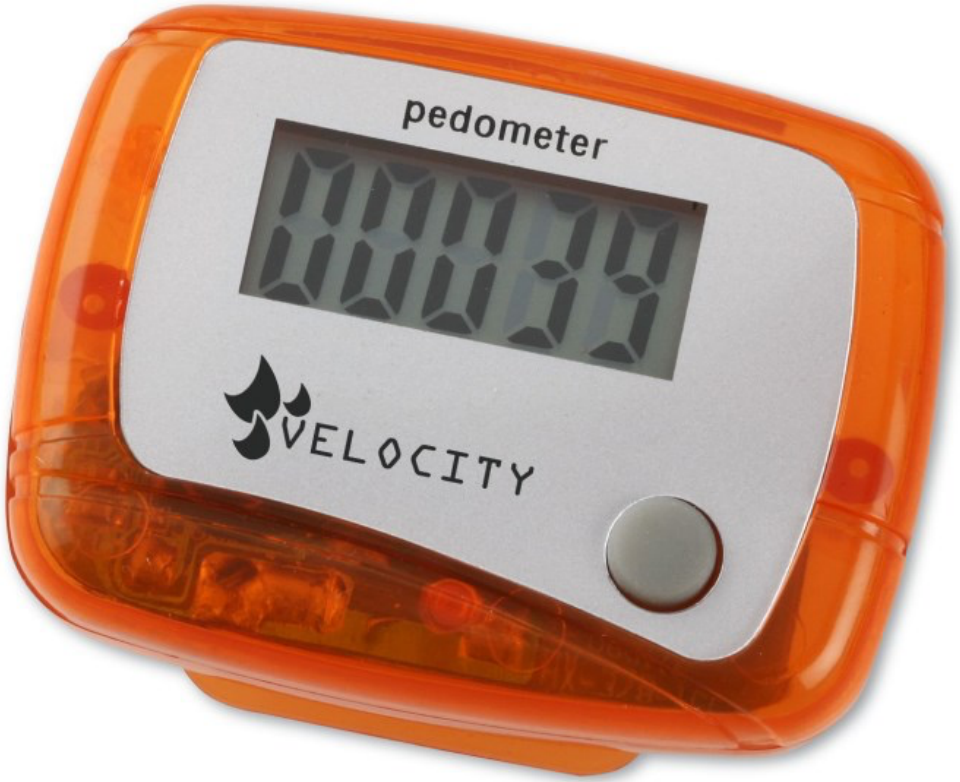
- *However, there's a thermometer in pretty much any smartphone, and some handsets might have more than one of them. The difference is that they're used to monitor the temperature inside the device and its battery. If a component is detected to be overheating, the system shuts itself down to prevent damage.*
- *And speaking of the Galaxy S4, it pioneered the use of an air humidity sensor in a smartphone. Data provided by it was used in the S Health application to tell whether or not the user was in their "Comfort Zone" – one with optimal air temperature and humidity.*

Fingerprint Sensor

- used to read fingerprints of a person and unlocks the device.

Air Humidity Sensor

Pedometer



Heart Rate Monitor

Detecting Harmful Radiation

Microphone and Camera

Other Sensors

- Radiation
- Air quality
- Alcohol
- Glucose
- Breath Analysis
- ----------
- Healthcare
  - One-lead ECG
  - Body temperature
  - Blood glucose
  - Heart rate
  - Blood oxygen saturation
  - Body fat percentage
  - Stress levels

Location Capabilities

- GPS
  - Precision of 20-50m
  - 3 satellites for 2D fix, 4 satelliter for 3D fix
  - Doesn’t work indoors, drains battery
- Cell tower triangulation
- Wifi network triangulation
- Indoor Locationing
- RFID
- Extended Large Tag NFC

Indoor Locationing Techniques

- Wifi/WLAN
  - WLAN “fingerprinting” makes it more accurate (database of Wifi signature data)
  - Often in combination with indoor maps
- Bluetooth
  - Range:10-30m, Precision: 5-10m (many access points required
- RFID
  - Up to 200m range
- UWB
  - High precision (<0.3m), high data rates, low range
  - Not in smartphones yet, high cost
- Zigbee
  - Same underlying technology as UWB, not available directly on smarphones today
- Ultrasound
  - High Precision (~1cm), lots of sensors, vulnerable to interference
- IR
  - Requires line of sight, very high precision (~1mm), superceded by other technologies


SENSORDRONE

Sensordrone - 11 Sensors For Your Smartphone

- **Precision Gas Sensor** - Test air quality, carbon monoxide levels
- **Reducing Gas Sensor** - Sense methane, propane, and natural gas leaks
- **Oxidizing Gas Sensor** - Ozone sensing and chlorine leaks
- **Non-Contact Thermometer** - Check food temperature, engine diagnostics, and whatever else you point it at
- **Humidity Sensor** - Check heat index, but also great for finding optimum food storage conditions, even preventing mold from growing in your home
- **Temperature Sensor** - Measure ambient temperature
- **Light Sensor** - For checking light intensity, sunlight monitoring, or even late-night refrigerator use
- **Color Sensors** - Use as a color meter, color matcher/analyzer, even pattern recognition
- **Pressure Sensor** - Works as a barometer or altimeter, and you can connect to a pressure cuff to act as a blood pressure monitor
- **Proximity Sensor** - Use it as a stud finder or liquid level monitor
- **Expansion Connector** - Digital (TTL UART & i2C) and analog (0-3V) interface for connecting other sensors like EKGs, Thermal Printers, and more

SensorDrone Requirements

- Android 2.2 (Froyo) and later.
- iOS 6.1 or later. Use with iPhone, iPod touch, and iPad. This app is optimized for iPhone 5.
- Includes Bluetooth 2.1 & 4.0 wireless communications.
- 0-3V Analog sensor or a digital (TTL UART or i2C) device, their API allows you to directly work with this signal WITHOUT any Bluetooth code.

Categorization

- **1. Devices using sensors – approach**
- Mobile phones, Smart Phones, Tablets: accelerometers, magnetometers, gyros, ambient light sensors, proximity sensors, temperature and humidity sensors, gas sensing
- Activity monitors: accelerometers, air pressure sensors
- Fitness and sport monitors: heart rate sensors, accelerometers, air pressure sensors
- Personal Health care; scale, temperature sensors, heart rate monitors
- Home medical devices: ECG/EKG monitors, blood pressure monitors, glucose monitors
- **2. Sensing Application – approach**
- Motion sensing: accelerometer, magnetometer, gyro, air pressure sensor
- Proximity sensing: optical methods, capacitive methods, other methods
- Gas sensing: semiconductor sensors, optical sensors, other methods
- **3. Market view and business point – approach**
- Market view
- Sensor and sensing cost and value
- IPR; patents and licensing

Time-Domain and Frequency Features

- Zero crossings: this is defined as the number of points where a signal crosses through a specific value corresponding to half of the signal range [8]. In our case, that specific point is the mean of a window segment.
- Root mean square value: The root mean square (RMS) of a signal, x, that represents a sequence of n discrete values x1, x2, …, xn is obtained using the following formula and can be associated with meaningful context information
- Spectral energy: The energy of the signal can be computed as the squared sum of its spectral coefficients normalized by the length of the sample window [8].
- Mean: This is the average value of all sample values in the sample window [8].
- Variance: This is the average of the squared differences of the sample values in a sample window from its mean [8].
- Standard deviation: This is the square root of variance [8].
- Median: This is defined as the value that divides the higher half of the sample window from the lower half [8].
- Sum of FFT coefficients: This is defined as the sum of the number of FFT coefficients [8]. In our case, we take the first five FFT coefficients, as these contain the main frequency components.