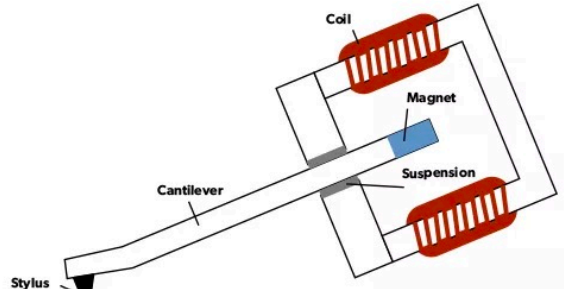
UNIVERSIDAD COMPLUTENSE MADRID

# IoT Node Architecture

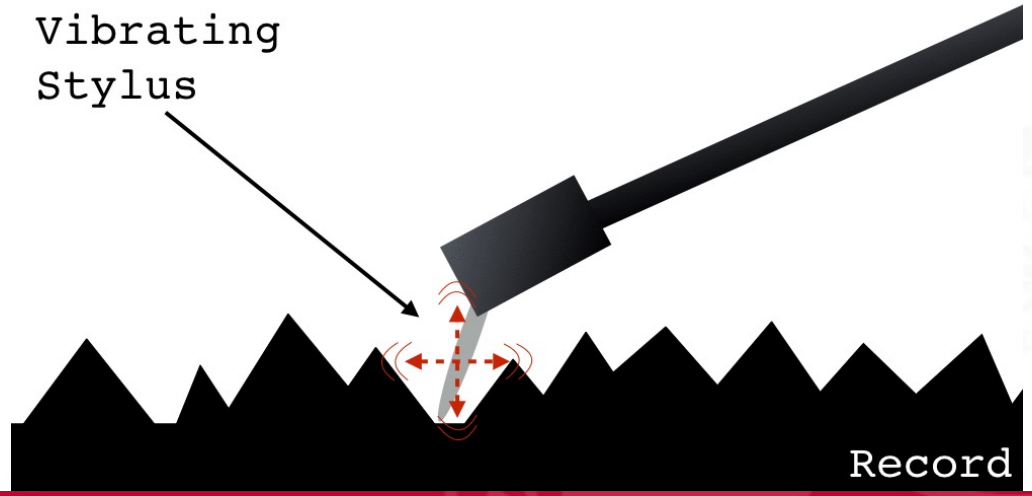
*About sensors*

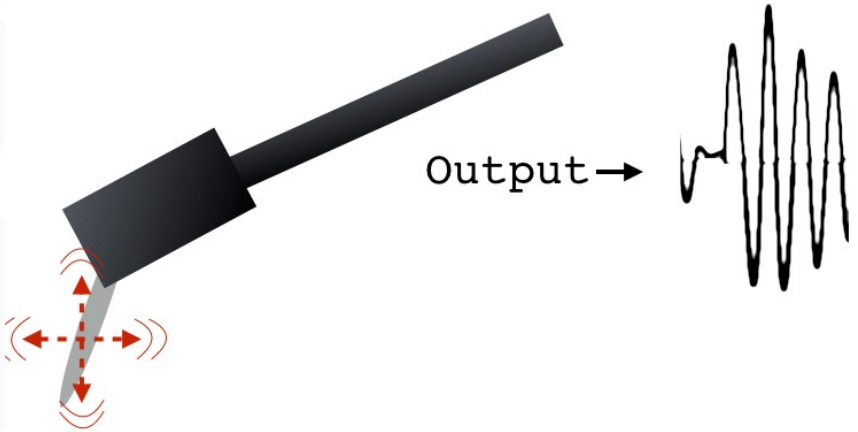
# Sensors

- What ‘s a sensor?
  - “Device that receives and responds to a signal or stimuli”



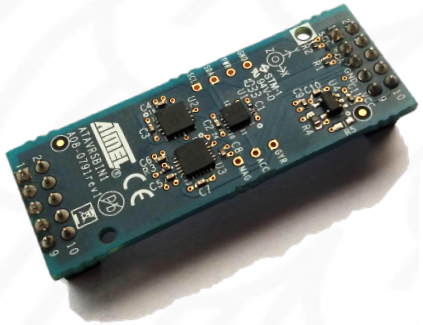

Electrical Current

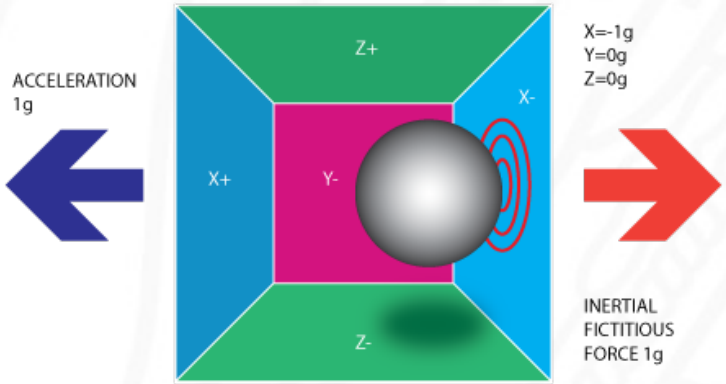


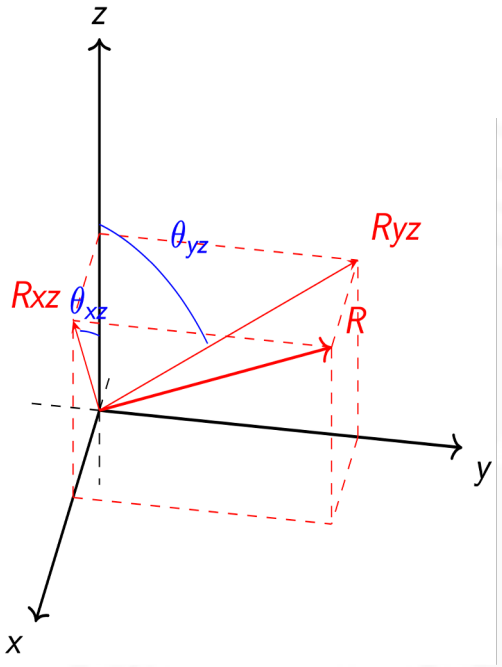



# Many sensores

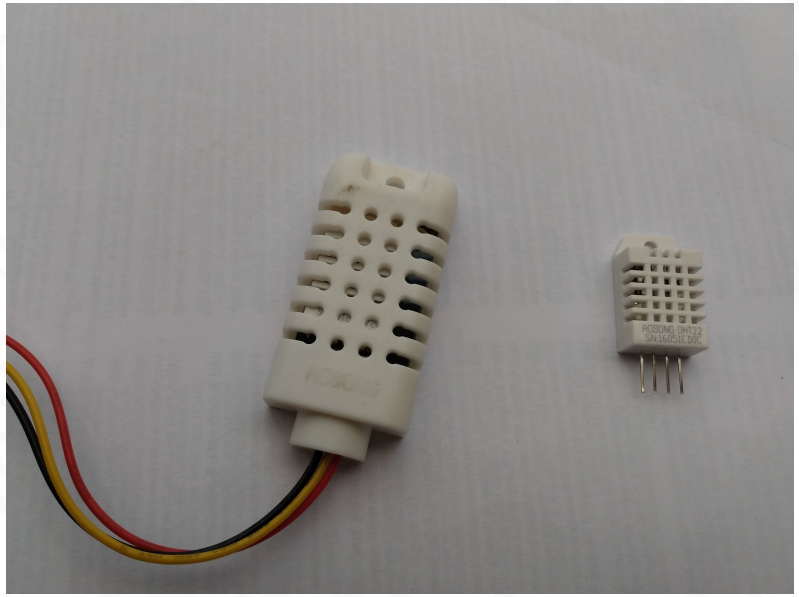
- Inertial Units (IMU)
  - Acceleromente, gyroscope, compass






- Temperature, humidity



# And more

- GPS (Global Positioning System)
  - GLONASS, GALILEO, BeiDOU
  - Provide latitude, longitude, current time
  - NMEA format
- Continuos *tracking* or spontaneous request
  - Check energy consumption!

**Tripmate 850 GPS logger. NMEA output**

```
$GPGGA,092750.000,5321.6802,N,00630.3372,W,1,8,1.03,61.7,M,55.2,M,,*76
$GPGSA,A,3,10,07,05,02,29,04,08,13,,,,,1.72,1.03,1.38*0A
$GPGSV,3,1,11,10,63,137,17,07,61,098,15,05,59,290,20,08,54,157,30*70
$GPGSV,3,2,11,02,39,223,19,13,28,070,17,26,23,252,,04,14,186,14*79
$GPGSV,3,3,11,29,09,301,24,16,09,020,,36,,,*76
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$GPGSV,3,2,11,02,39,223,16,13,28,070,17,26,23,252,,04,14,186,15*77
$GPGSV,3,3,11,29,09,301,24,16,09,020,,36,,,*76
$GPRMC,092751.000,A,5321.6802,N,00630.3371,W,0.06,31.66,280511,,,A*45
```
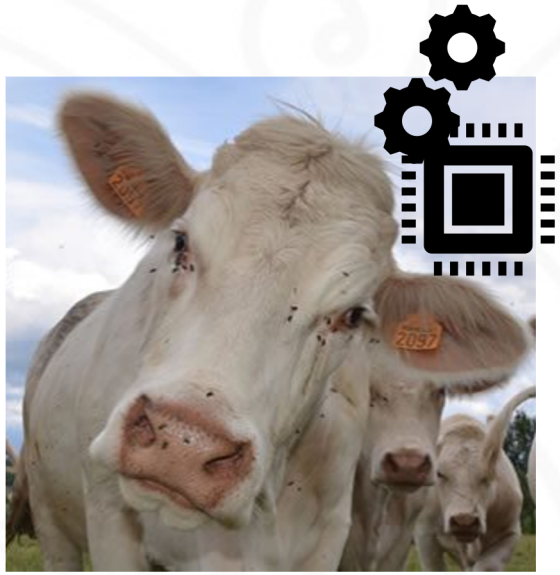
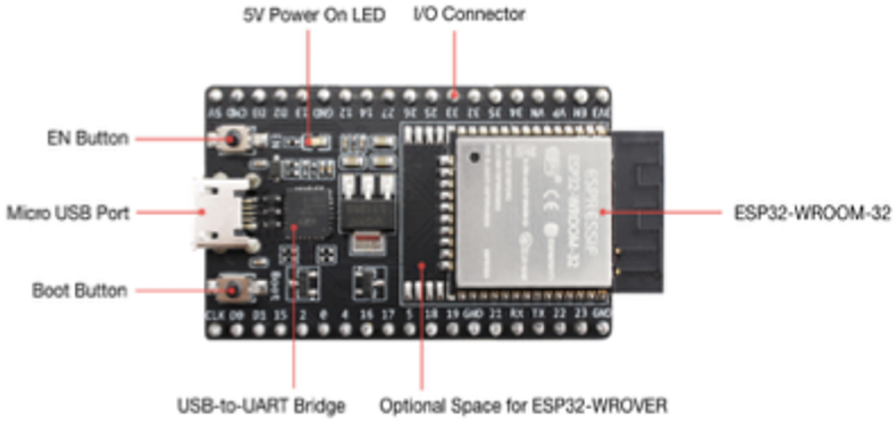

# Cameras

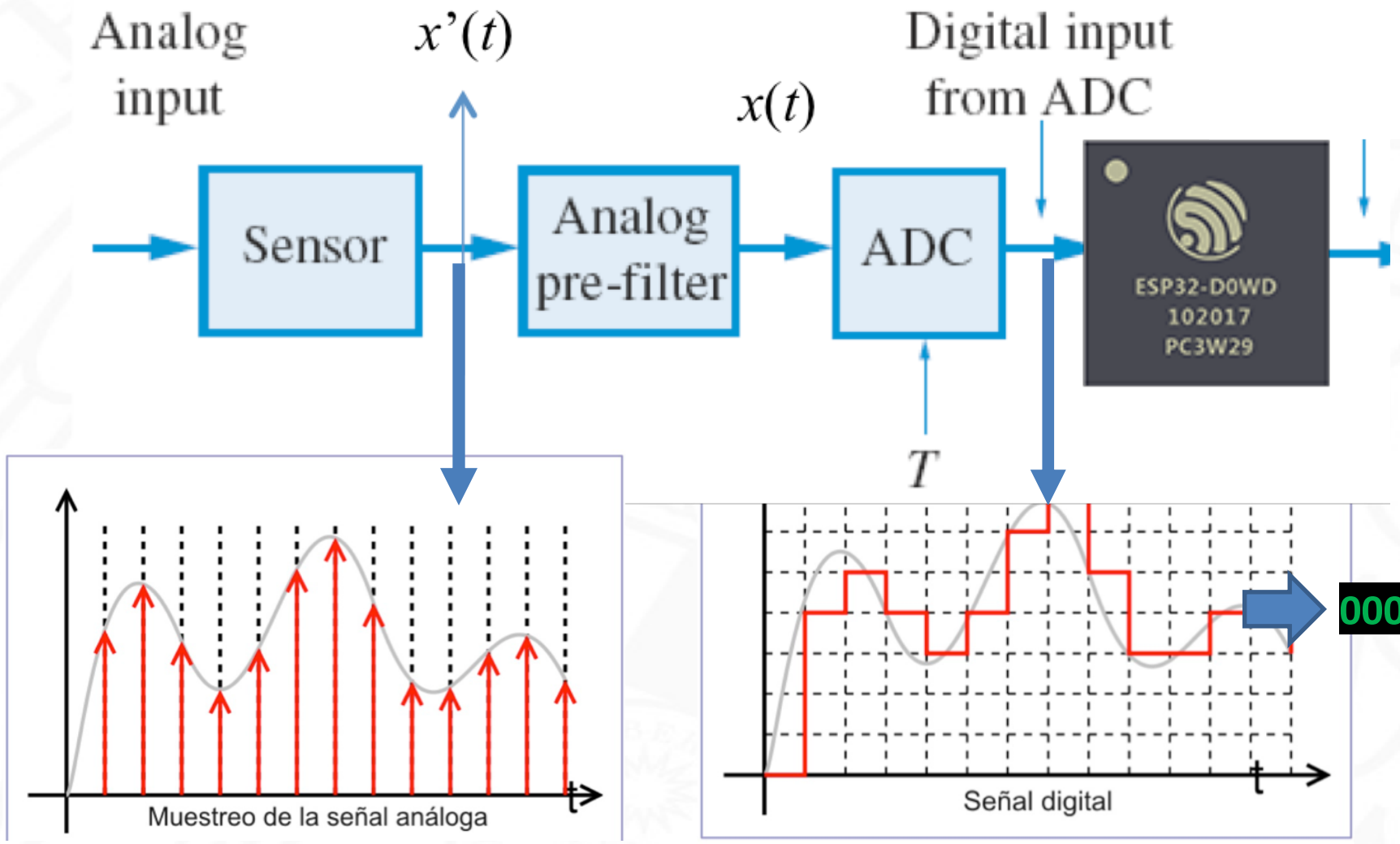
# How are we using sensors?

- They provide an electrical analog signal
- How are we translating that signal to something that our CPU can understand and hadle?



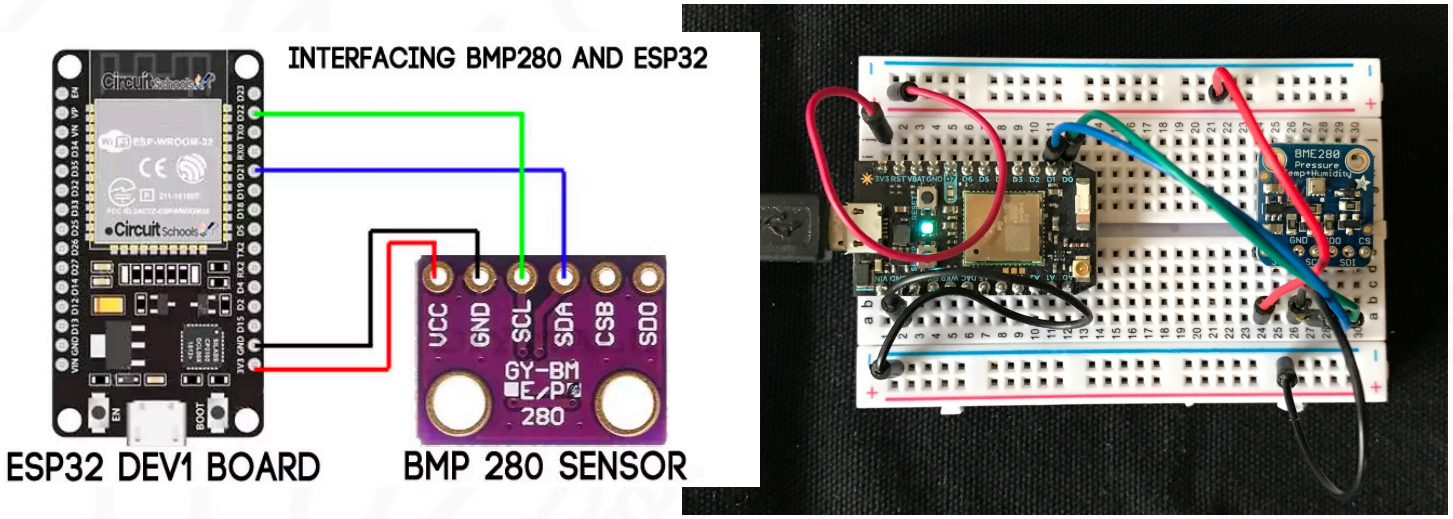


# Processors are digitals!



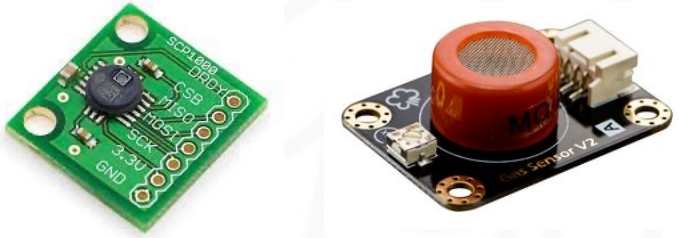
# Building prototypes

- Dev. Boars with SoC and pins
- May have on-board sensors
- Or we may need to externally connect them
  - Directly to our ADC
  - Using standard bus: I2C, SPI,  UART
    - Sensor board includes its own ADC




**Placa basada en ESP32. Conexión en *protoboard***

**I2C**. Sensores de luz ambiental, temperatura, presión



**SPI**. Sensores de presión atmosférica, calidad de aire (CO)

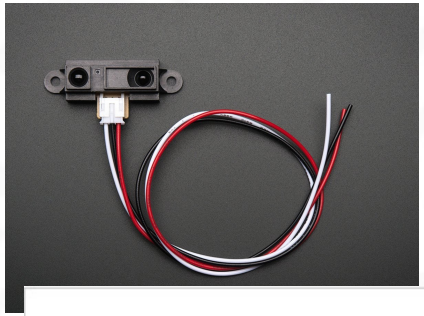
# Many sensor types

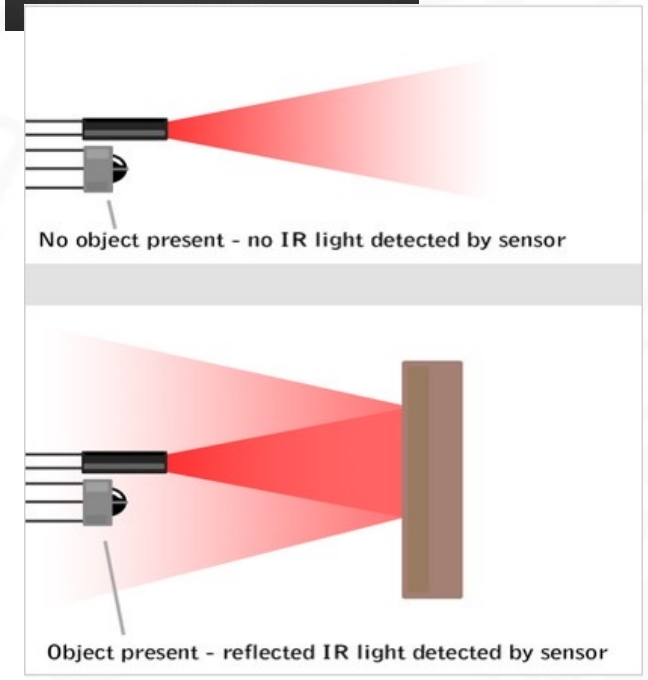
| Conversion Phenomena | | |
|---|---|---|
| | Physics | Thermoelectric |
| | | Phototelectric |
| | | Photomagnetic |
| | | Electromagnetic |
| | Chemistry | Chemical transormation |
| | | Electrochemical process |
| | | Spectroscopy |
| | Biologic | Biochemical transformations |
| | | Effect in a test organism |
| | | Spectroscopy |

# Presence / distance sensors

## Infrarrojos

- Activos



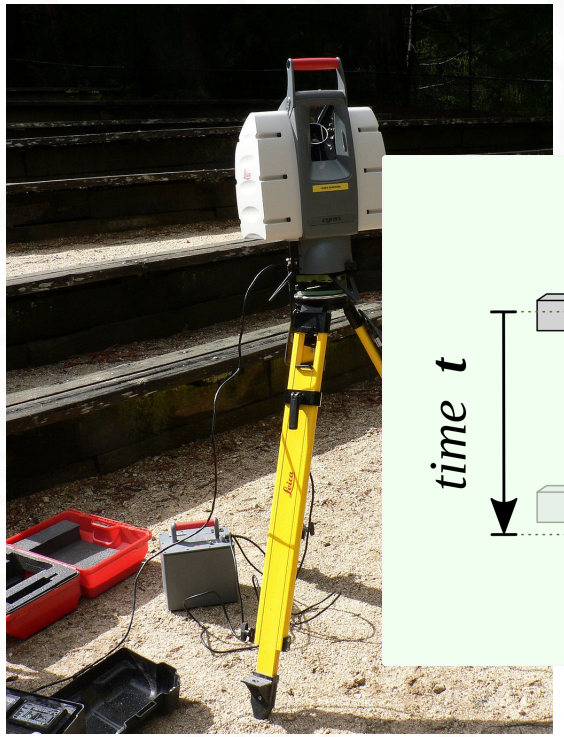


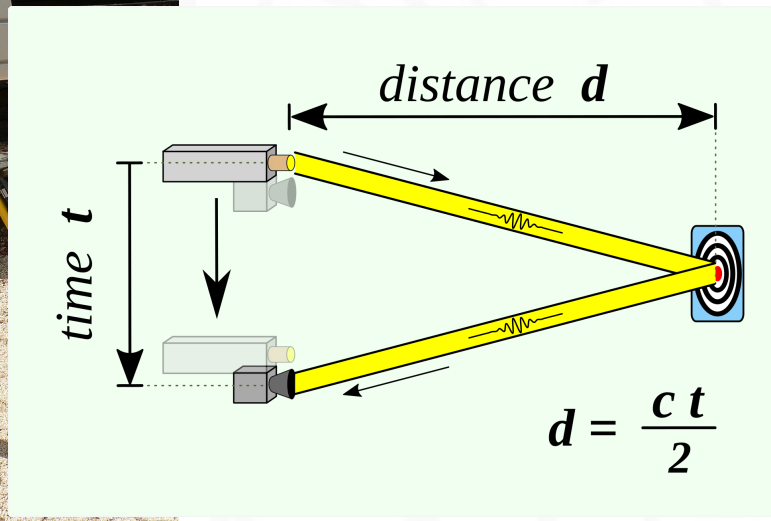

- Pasivos

Sensor PIR

Cámara de infrarrojos

## LIDAR

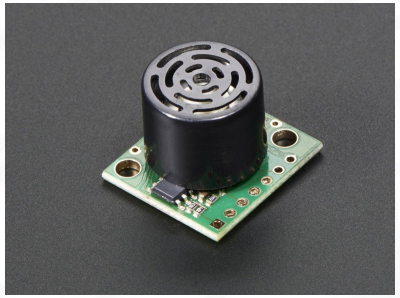


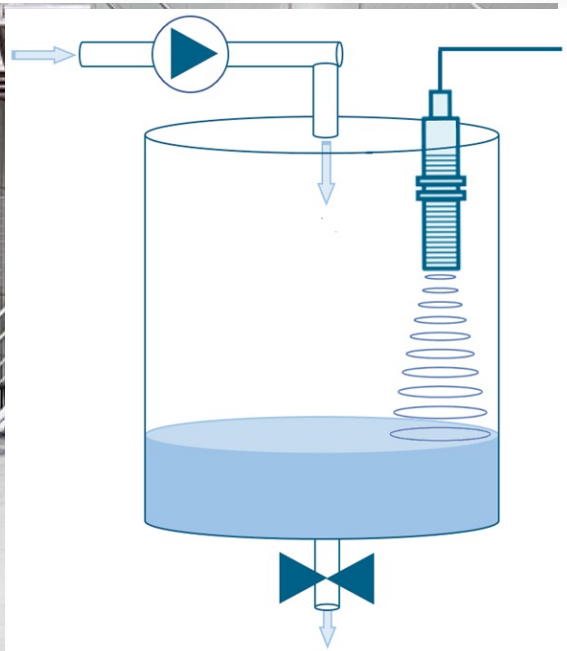


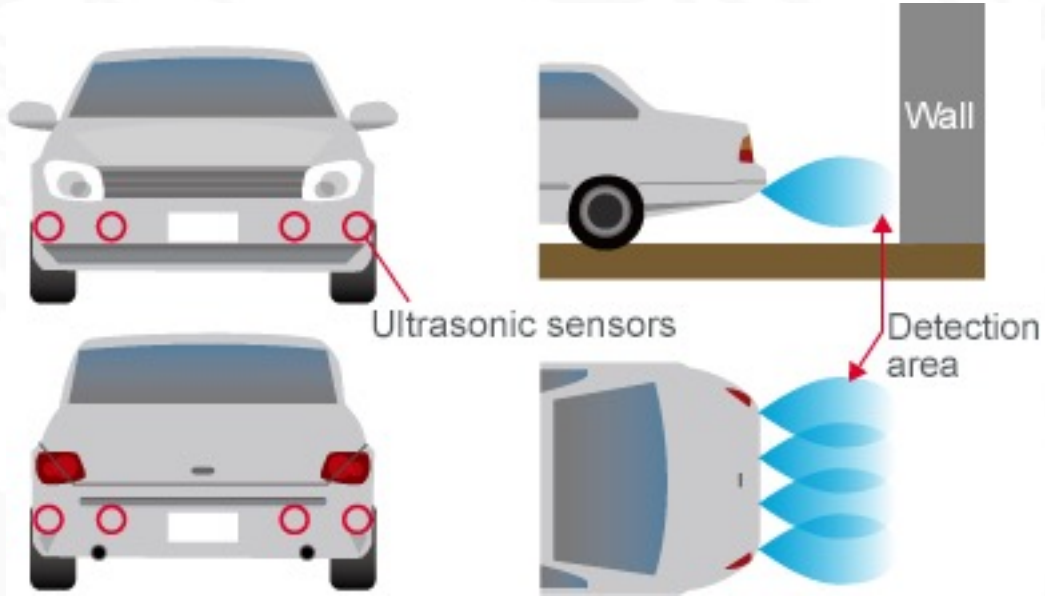

This Leica terrestrial lidar
Fuente: Wikipedia

# Presence / distance sensors

- Ultrasonic





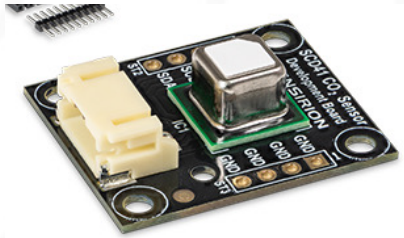



Tank levels, containers...

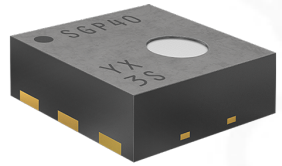
# Enviromental sensors

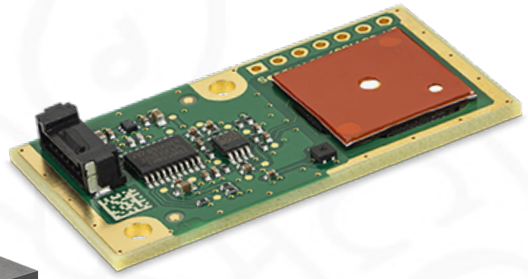
- CO - CO2 – VOC
- PM 2.5 – PM 10
- Humidity - Temperature
- Ambient light
- Noise

**I2C interface**




SCD41 development board

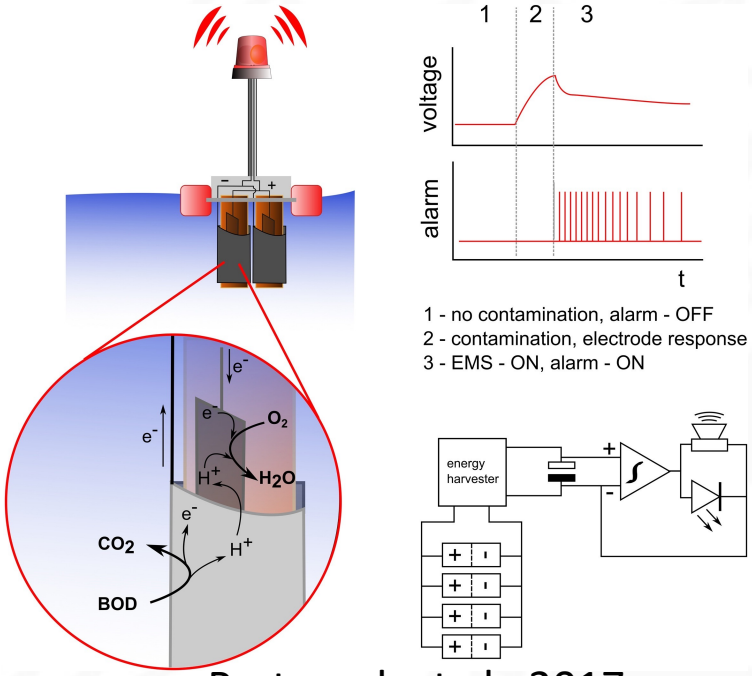


**Complete solucion**

# Water quality

- Biosensors
  - Biological elements detect the concentration of a substance
    - Enzimas, antibodies...
  - Those elements change when they contact the substance
    - Temperatura change, resistance, colour...
  - A transductor reads that change and transfrom it in electrical signal




Pasternak et al, 2017.

# Supplies (power, water..)

- SmartMetering
  - Electricity: Wattimetro
  - Water / gas: flowmeter

- Discover leaks
  - Stretch counters
  - Hydrophone (acoustic)

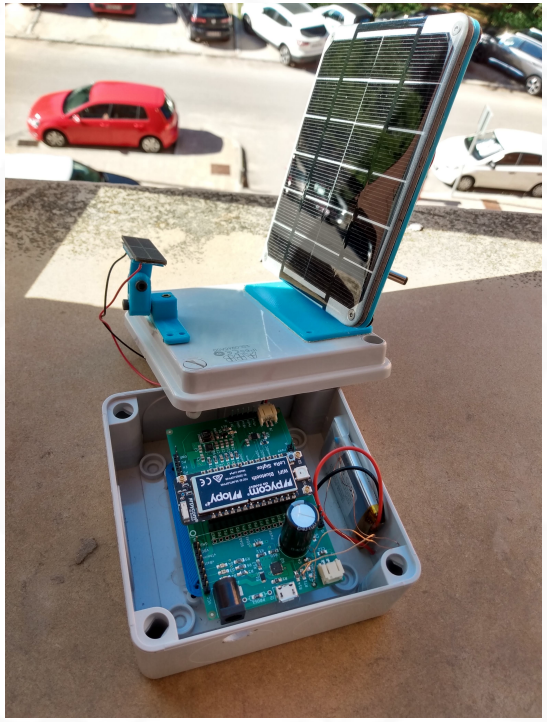
- Careful: water is not gas
  - Security: avoid sparks!

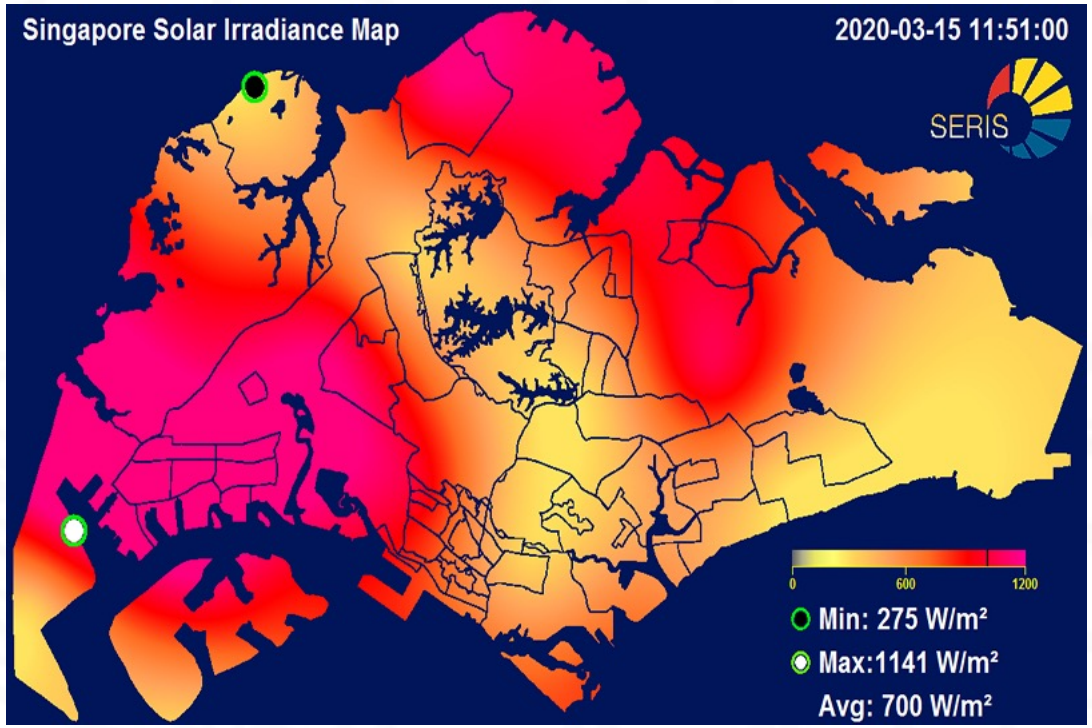
# Parking sensors

https://www.the-iot-marketplace.com/solutions/smart-parking

# Solar radiation sensors

- Pyranometers
- Low cost version





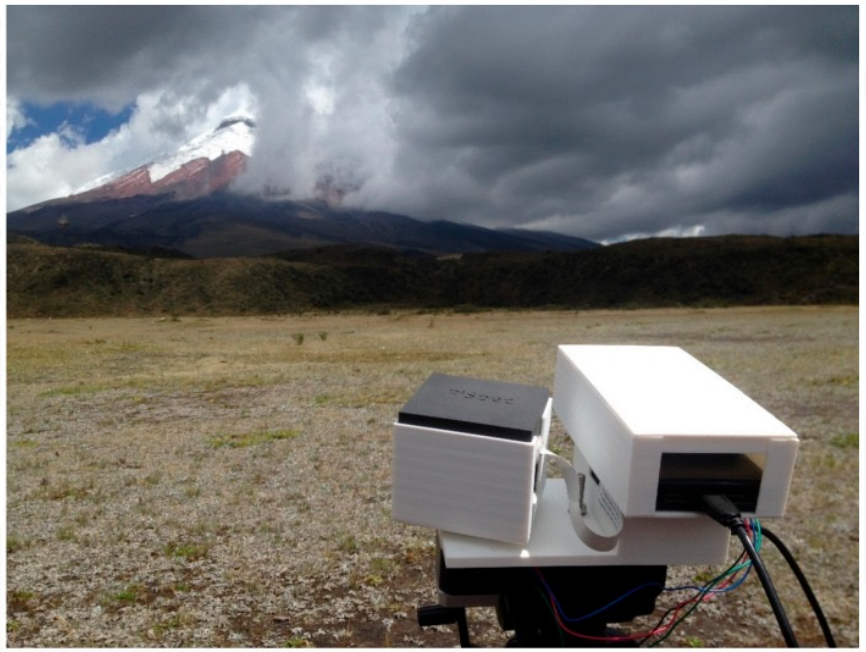

https://www.seris.nus.edu.sg/services/Real-Time-Monitoring-System-of-Irradiance.html

# Hyperspectal and thermal cameras

- Thermal cameras for traffic management
  - More robustness to light changes

https://www.flir.com/products/its-series/

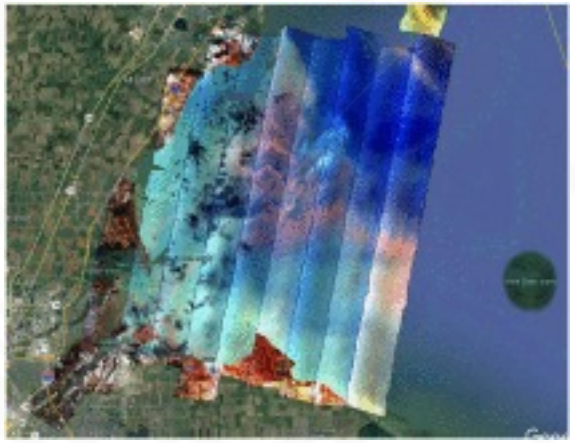
- Hyperspectral images
  - Green spots registration, water supply
  - Enviromental sensor



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6678368/

# Hyperspectral for water quality monitoring

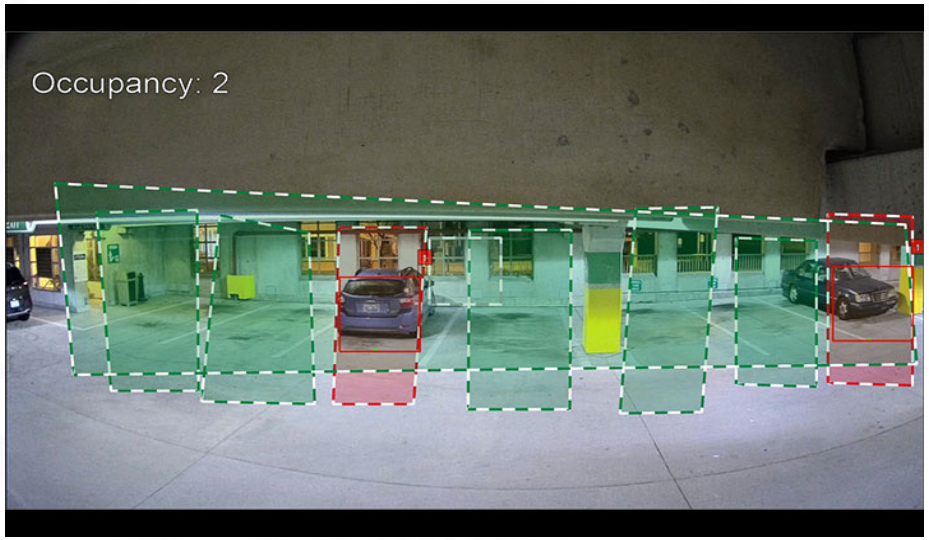
- Air and satellite images
  - Allow to detect harmful algae, too much clorophyll, cyanobacteria...



John Lekki et al. “Airborne hyperspectral and satellite imaging of harmful algal blooms in the Great Lakes Region: Successes in sensing algal blooms” Journal of Great Lakes Research, 2019

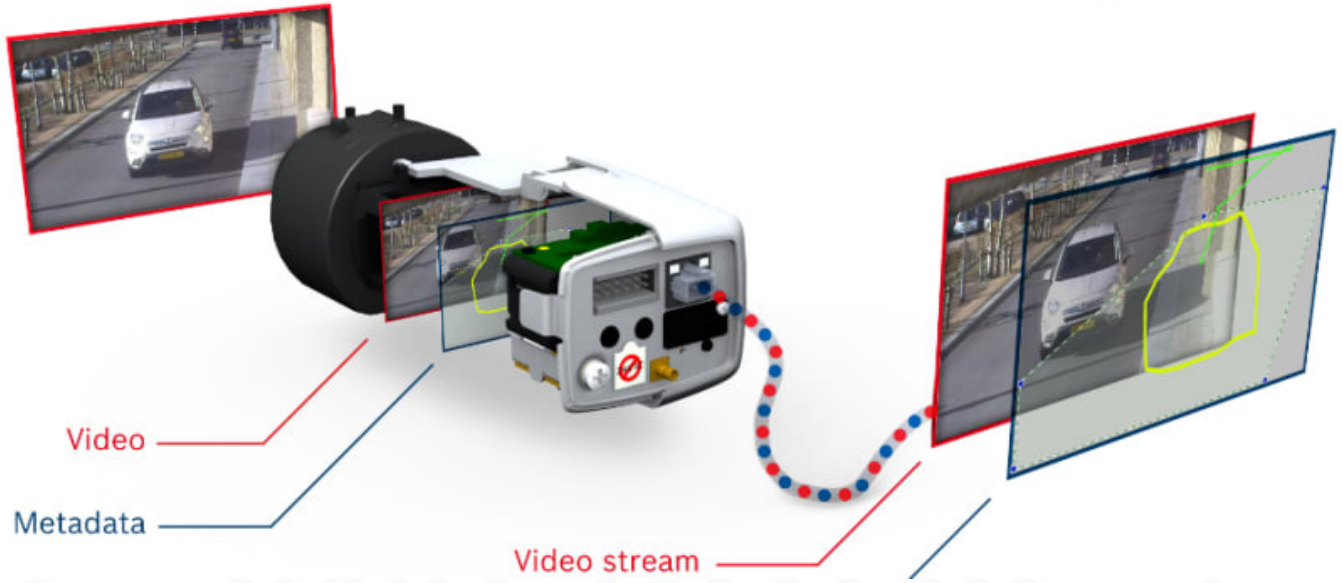
# And regular cameras

**Flexidome 8000**




**Inteox 7000**

BOSCH
Invented for life



# In-camera video processing

- Send video to the cloud is too costly
  - Bandwitdh
  - Computationally expensive (not scalable)
- Many cameras ship their own processing elements
  - …. And some smart configurable process
- Machine learning is a main topic there