Advanced Communication Technologies (CCE534)

Lecture 2

IoT Architecture and Core IoT Modules

(Sensors)

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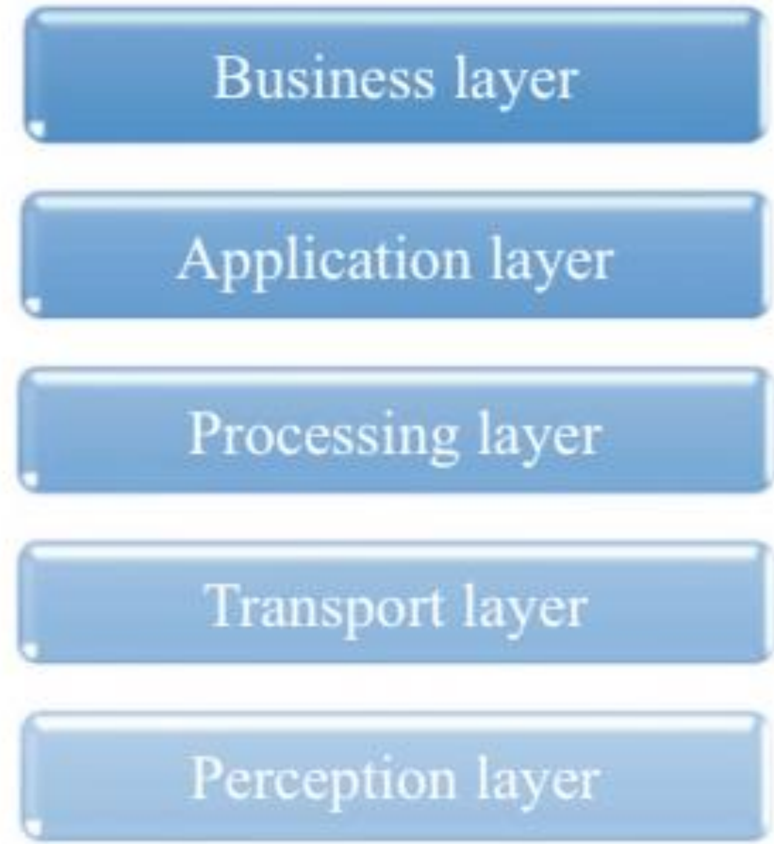
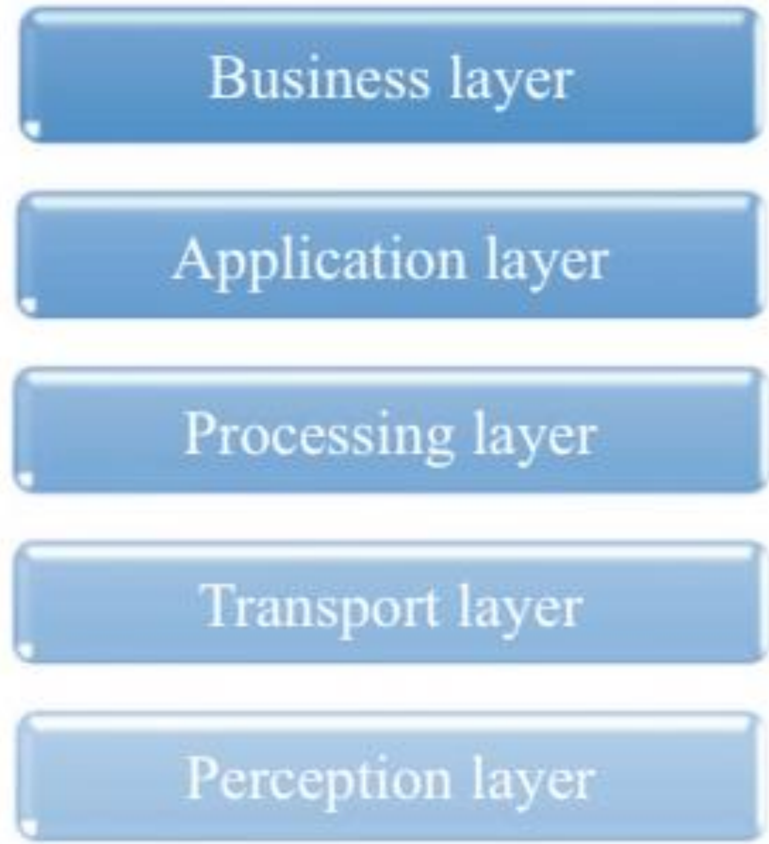
- **The 5-Layers IoT Architecture**



1. The perception layer:

- **is the physical layer with environmental information sensors that are used to sense some physical parameters**

- **The 5-Layers IoT Architecture**



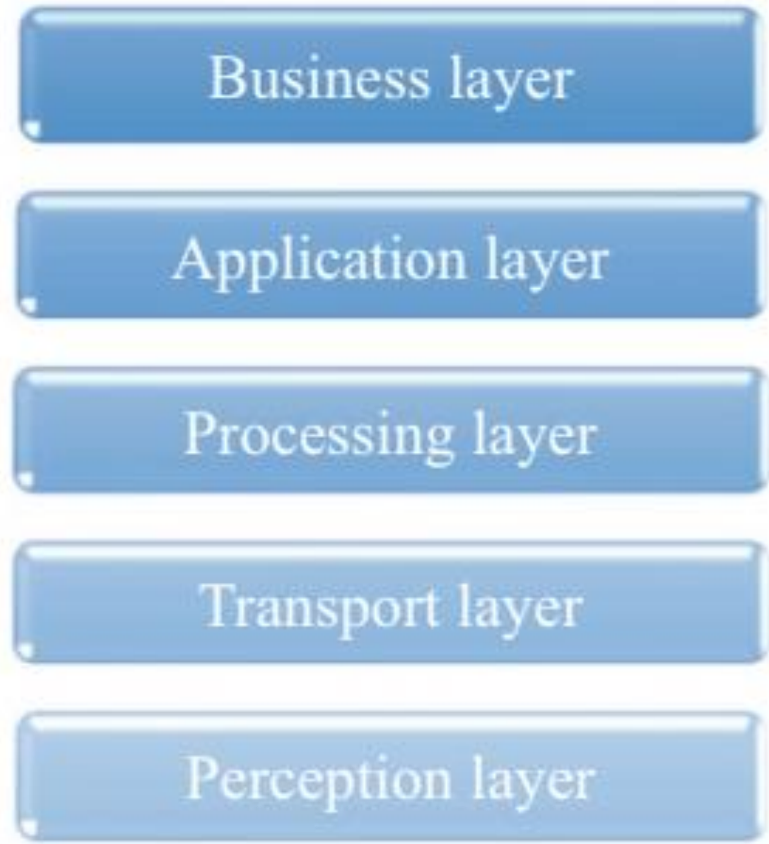
2. The Transport layer:

- **transfers sensor data from the perception layer to the processing layer and vice versa via networks such as Bluetooth, wireless, 3G, 4G, 5G, LAN, NFC, LoRA, and RFID.**

- **The 5-Layers IoT Architecture**

3. The Processing layer:

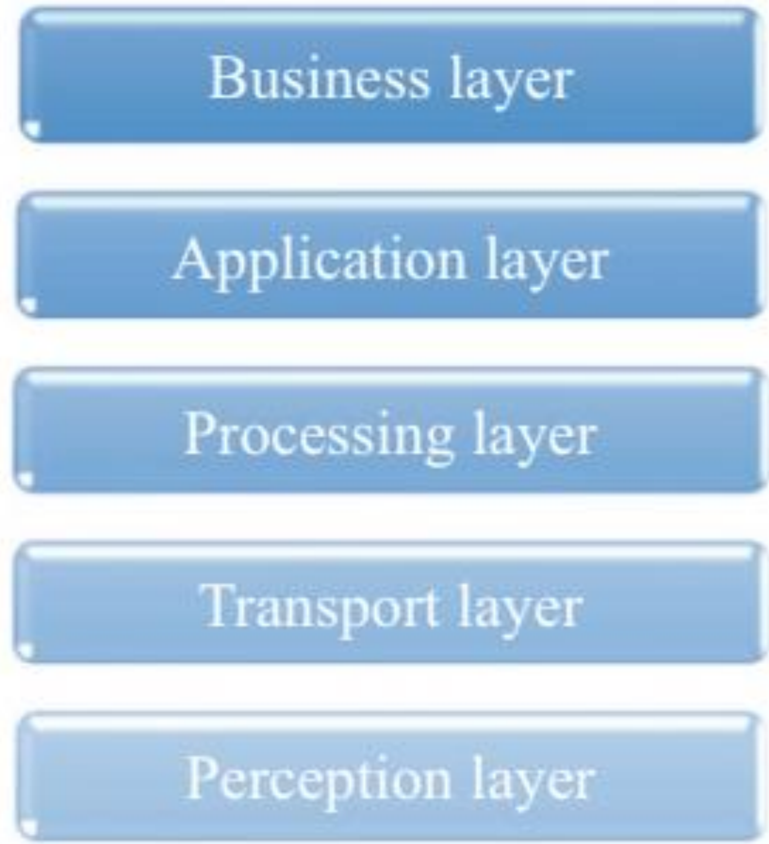
- The processing layer is also referred to as the middleware layer.
- It can store, analyze, and process large quantities of transportation data
- It can manage and provide a variety of lower layers of services.
- It uses many technologies, such as databases, cloud computing, and big data processing modules.



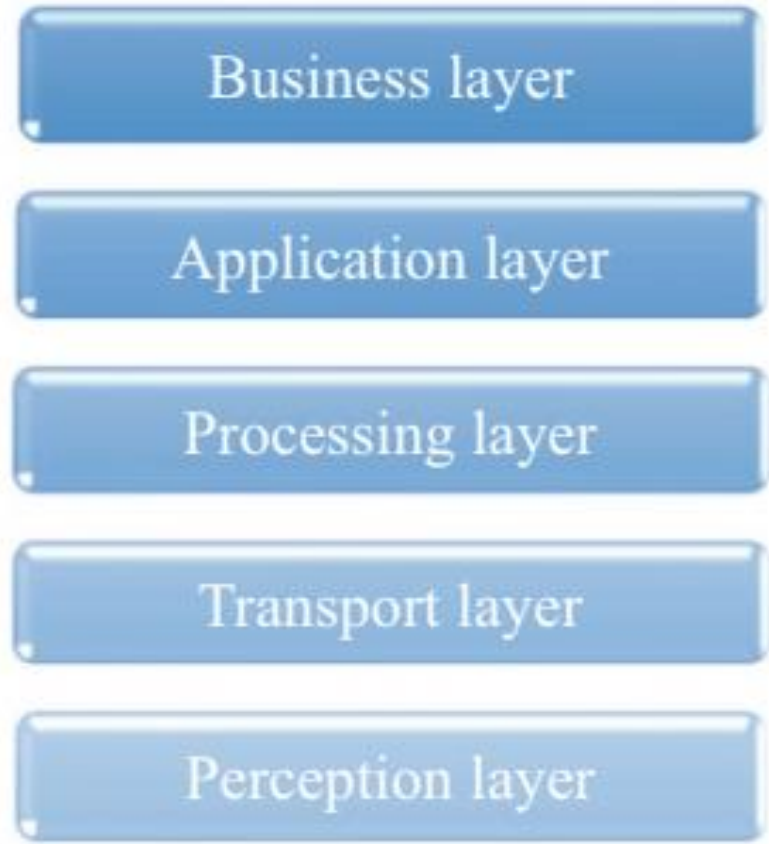
- **The 5-Layers IoT Architecture**

4. The Application layer:

- The application layer is responsible for providing the user with specific application services.
- It defines different applications for the IoT, such as smart homes, smart cities, and intelligent health.



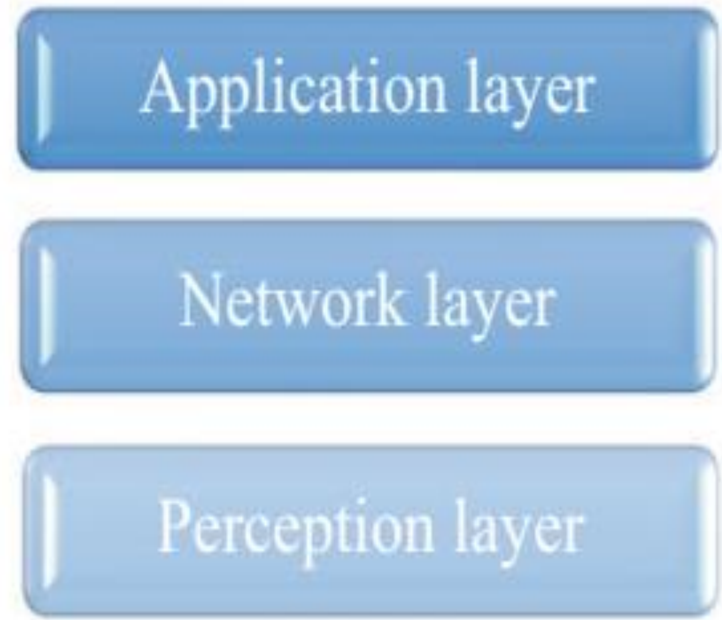
- **The 5-Layers IoT Architecture**



5. The Business layer:

- **The entire IoT system is managed by the business layer, including applications, business models, and user privacy**

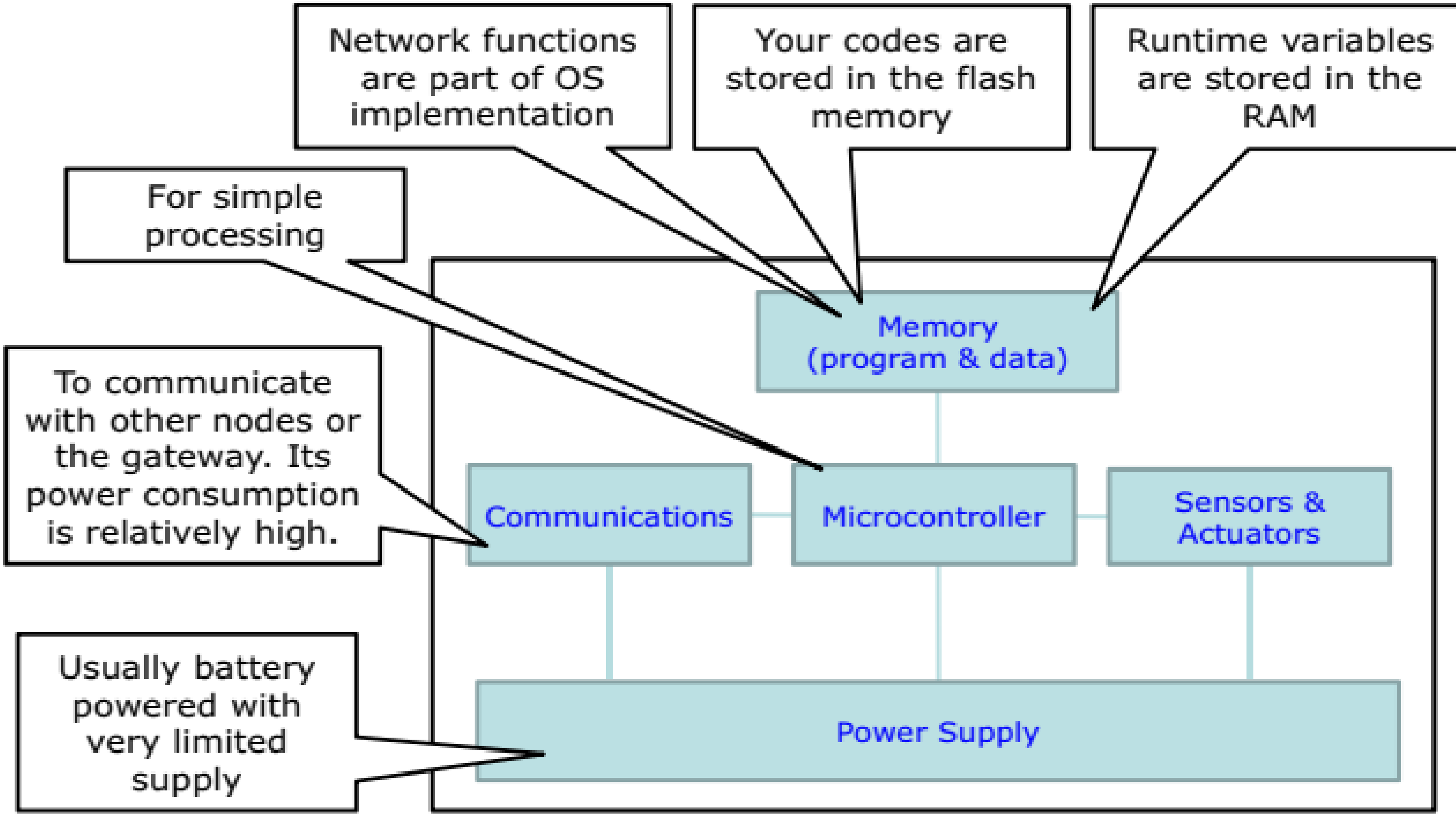
- **The 3-Layers IoT Architecture**



- **Some other references define only a 3-layer architecture**
- **The three-layer architecture defines the main idea of IoT, but it is not sufficient for IoT research, because research often focuses on the finer aspects of IoT**

IoT Nodes Architecture

- We can turn almost every object into a "thing".
- A "thing" still looks much like an embedded system
- A "thing" generally consists of some main parts:



Endpoints (Sensors and Transducers)

Endpoints:

- The Internet of Things (IoT) begins with endpoints that are the things associated with the internet
- Those endpoints are either sources of data (Sensors) or devices that perform an action (Actuators).
- It is referred usually as input and output transducers as they convert or transduce energy of one kind into another.

  - ✓ For example, in a sound system, a microphone (input device) converts sound waves into electrical signals for an amplifier to amplify and
  - ✓ A loudspeaker (output device) converts these electrical signals back into sound waves.

Endpoints (Sensors and Transducers)

Sensors:

- They are mainly input components in IoT
- A sensor detects (senses) changes in the ambient conditions or in the state of another device or a system
- They are devices that receive a stimulus and responds with an electrical signal (usually)
- The sources that output a stream of time-correlated data that must be transmitted securely, possibly analyzed, and possibly stored

Main Sensors Features :

1. It is only sensitive to the measured property (e.g., A temperature sensor senses the ambient temperature of a room.)

2. It is insensitive to any other property likely to be encountered in its application (e.g., A temperature sensor does not bother about light or pressure while sensing the temperature.)

3. It does not influence the measured property (e.g., measuring the temperature does not reduce or increase the temperature)

Sensor Resolution:

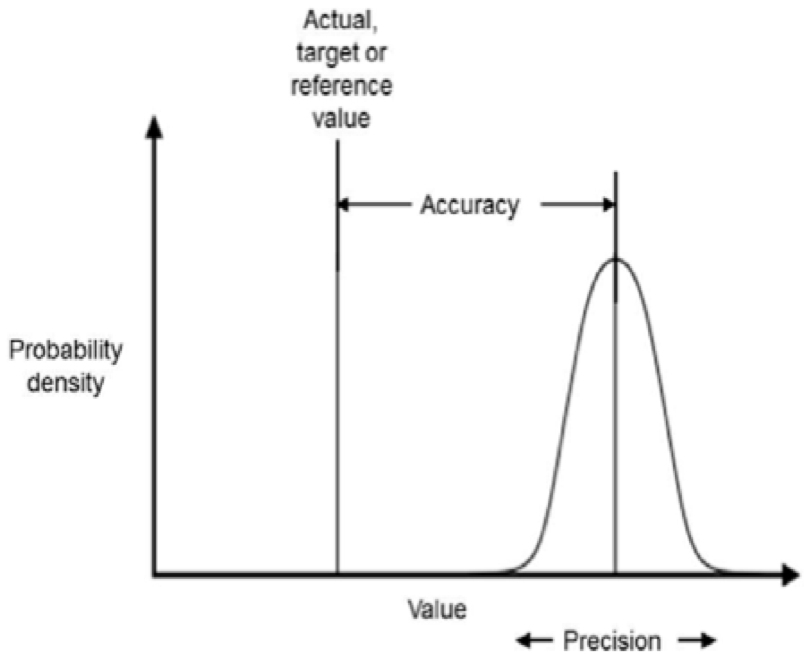
- **The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring.**
- **It is important in identifying input changes at low signal levels from noise in the application.**
- **An analog to digital converter (ADC) that quantizes the smooth output of an analog sensor for use in a digital control application has increased resolution as the number of bits increases.**
- **Take two scales, for example:**
  - ✓ One scale measures to two decimal places (.01 kg), and
  - ✓ Another scale measures to a whole integer (1 kg).
- **The scale that measures by 0.01 kg is much more sensitive to changes in weight, and will provide finer readings.**

Sensor Accuracy versus Precision

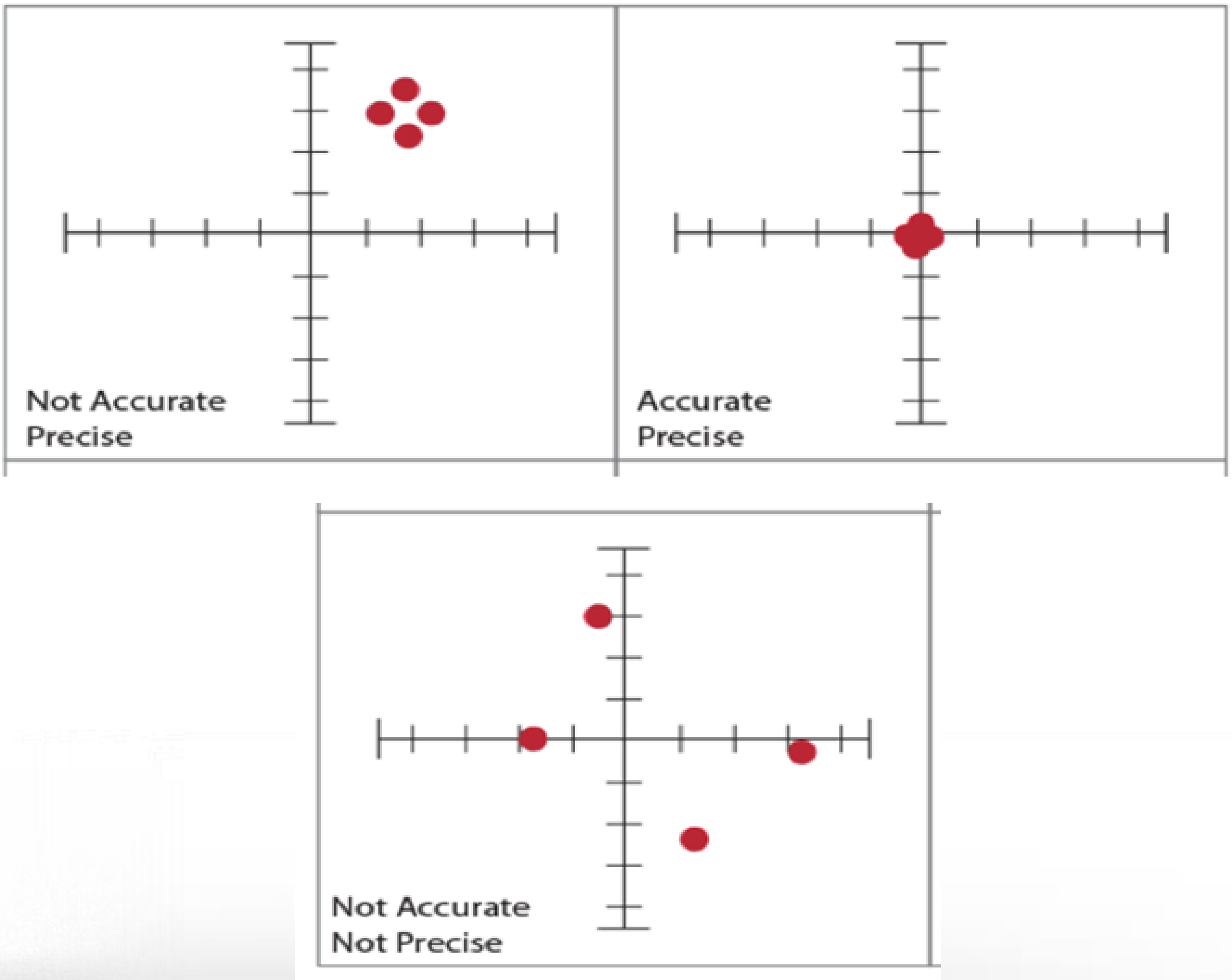
- Accuracy and precision are frequently used interchangeably, However, there are obvious differences between the two specifications.
- If exactly the same value is measured a number of times, an ideal sensor would output exactly the same value every time.
- But real sensors output a range of values distributed in some manner relative to the actual correct value.

- Accuracy is the degree of exactness between actual measurement and true value

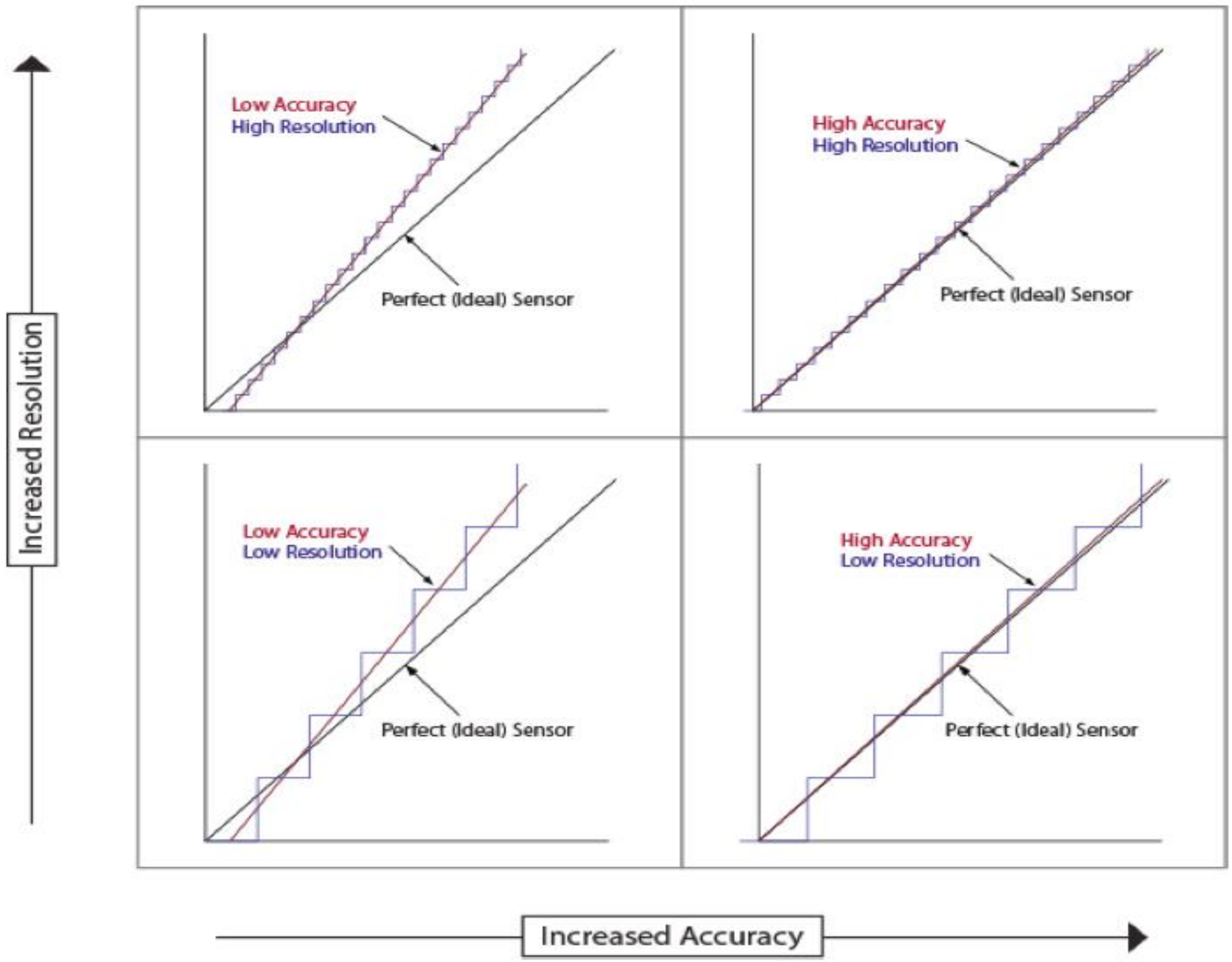
- precision is the degree of *reproducibility* of a measurement.



Sensor Accuracy versus Precision

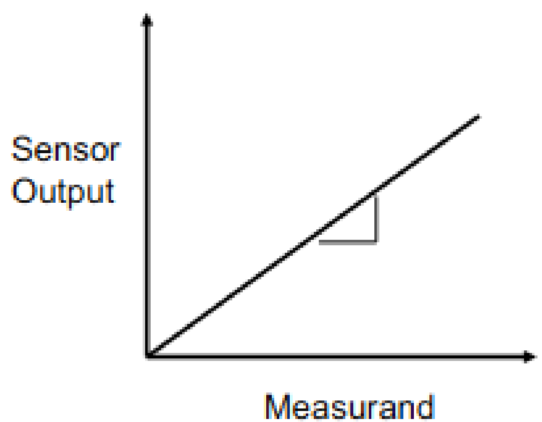


Sensor Accuracy versus Resolution

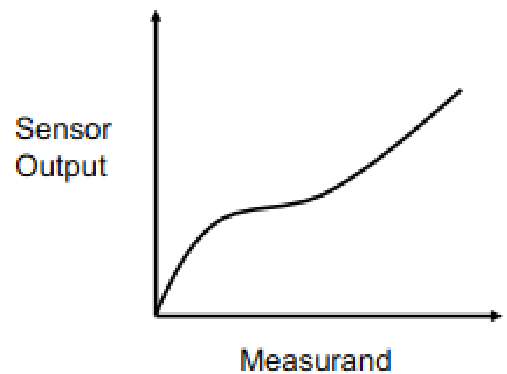


Sensor Sensitivity:

- **The sensitivity can be defined using the slope of the output characteristic curve (dY/dX)**
- **Sensitivity: is the minimum input of a physical parameter that will create a detectable output change.**
- **In some sensors, the sensitivity is defined as the input parameter change required to produce a standardized output change.**



Ideal



Practically, we have Sensitivity error

Sensor classifications/Classes

- Active versus Passive sensors
- Analog versus Digital
- Scalar versus vector
- Linear versus Non-Linear characteristic curve

Sensor classifications/Classes

Passive versus Active Sensors

- **Active sensors radiate some sort of signal that interact with the environment such as sonar and radar sensors**

- **Passive filters do not radiate signals but detect the presence of other signals such as mic**

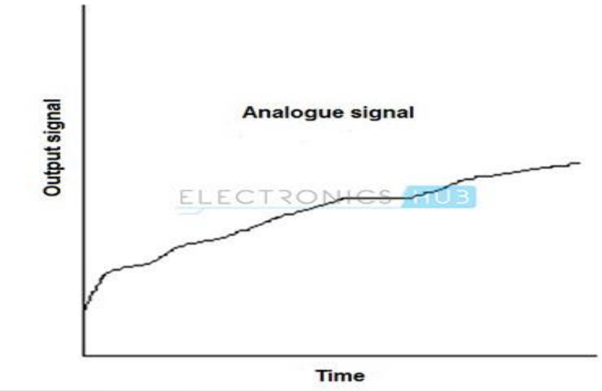
Sensor classifications/Classes

Analog Sensors

- produce a continuous output signal or voltage which is generally proportional to the quantity being measured.
- Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc. are all analog quantities as they tend to be continuous in nature.

Digital Sensors

- produce discrete digital output signals or voltages that are a digital representation of the quantity being measured.
- Digital sensors produces discrete (non-continuous) values, which may be output as a single "bit" or by combining the bits to produce a single "byte"



Sensor classifications/Classes

Scalar Sensors

- produce output signal or voltage which is generally proportional to the magnitude of the quantity being measured.
- Physical quantities such as temperature, color, pressure, strain, etc. are all scalar quantities as only their magnitude is sufficient to convey an information.
- For example, the temperature of a room can be measured using a thermometer or thermocouple, which responds to temperature changes irrespective of the orientation of the sensor or its direction

Vector Sensors

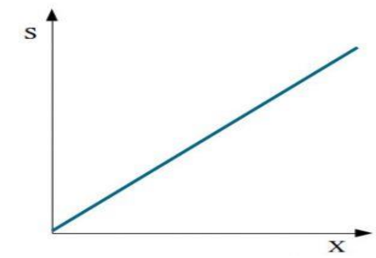
- **produce output signal or voltage which is generally proportional to the magnitude, direction, as well as the orientation of the quantity being measured.**

- **Physical quantities such as sound, image, velocity, acceleration, orientation, etc. are all vector quantities, as only their magnitude is not sufficient to convey the complete information.**

- **For example, the acceleration of a body can be measured using an accelerometer, which gives the components of acceleration of the body with respect to the x,y,z coordinate axes.**

Linearity of the Characteristics curve (transfer Function)

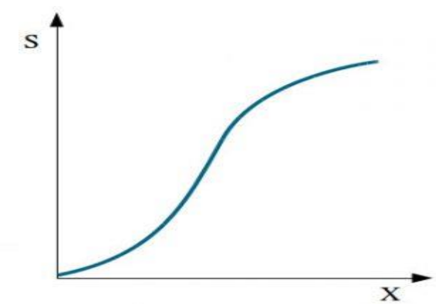
- A transfer function for a sensor is a mathematical function representing the input-output relation.
  - ✓ Input: a physical measured parameter
  - ✓ Output: usually an electrical output signal.



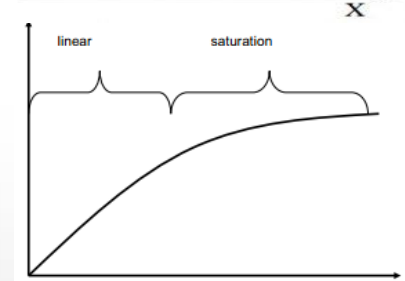
- It describes the system response of a sensor.
- The simplest form of transfer function is a linear function which can be described as follows

$$S = a + bx$$

- ✓ x is the input,
- ✓ b is the slope (or sensitivity), and
- ✓ a is the offset (or the output when the input is zero)



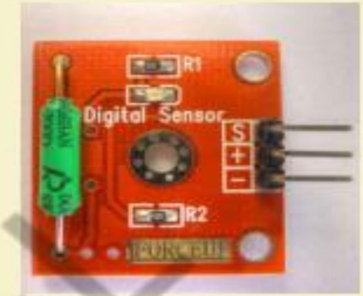
- Hardly any sensor produces linear transfer function,
- there is always some nonlinearity in the function



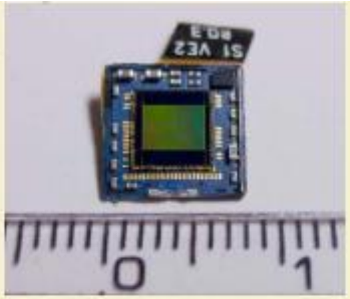
Samples of Sensors' Types

Pressure Sensor

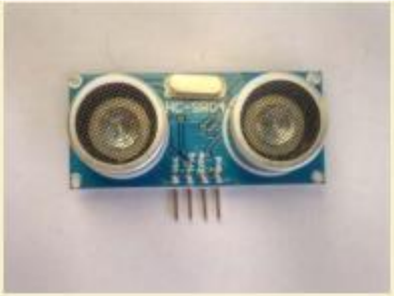
Analog Temperature Sensor
Source: Wikimedia Commons



Tilt Sensor
Source: Wikimedia Commons



Camera Sensor
Source: Wikimedia Commons



Ultrasonic Distance Sensor
Source: Wikimedia Commons

Do all sensors have the same technology?

Samples of Sensors' Types

Light	• Light Dependent resistor • Photo-diode
Temperature	• Thermocouple • Thermistor
Force	• Strain gauge • Pressure switch
Position	• Potentiometer, Encoders • Opto-coupler
Speed	• Reflective/ Opto-coupler • Doppler effect sensor
Sound	• Carbon Microphone • Piezoelectric Crystal
Chemical	• Liquid Chemical sensor • Gaseous chemical sensor

Sensors Technologies: A Quick Overview

- Capacitive
  - A change in capacitance with a change in environment
    - Can detect liquids and objects based on their dielectric constant
    - Can take human body capacitance as input
  - For detection of displacement, humidity, acceleration, human contact, etc.

- Resistive
  - A change in resistance with a change in environment
    - Physical changes include light, force, heat, magnetic field, etc.
  - For detection of light, force, heat, etc.
  - Applications include camera, street lights, music instruments, weight sensing, touch screen, etc.

Sensors Technologies: A Quick Overview

- Magnetic
  - There are several approaches for magnetic sensing, eg. Hall effect sensor, magneto-diode, magneto-transistor, etc.
  - Generally, they detect magnetic fields or their alteration by ferromagnetic objects.
  - For measuring of rotary movement, Earth's magnetic field, etc.

- Inductive
  - A change in the amplitude of an emitted high frequency electromagnetic field the oscillations.
  - For detection of metallic object and different metals
  - Common in vehicle detection

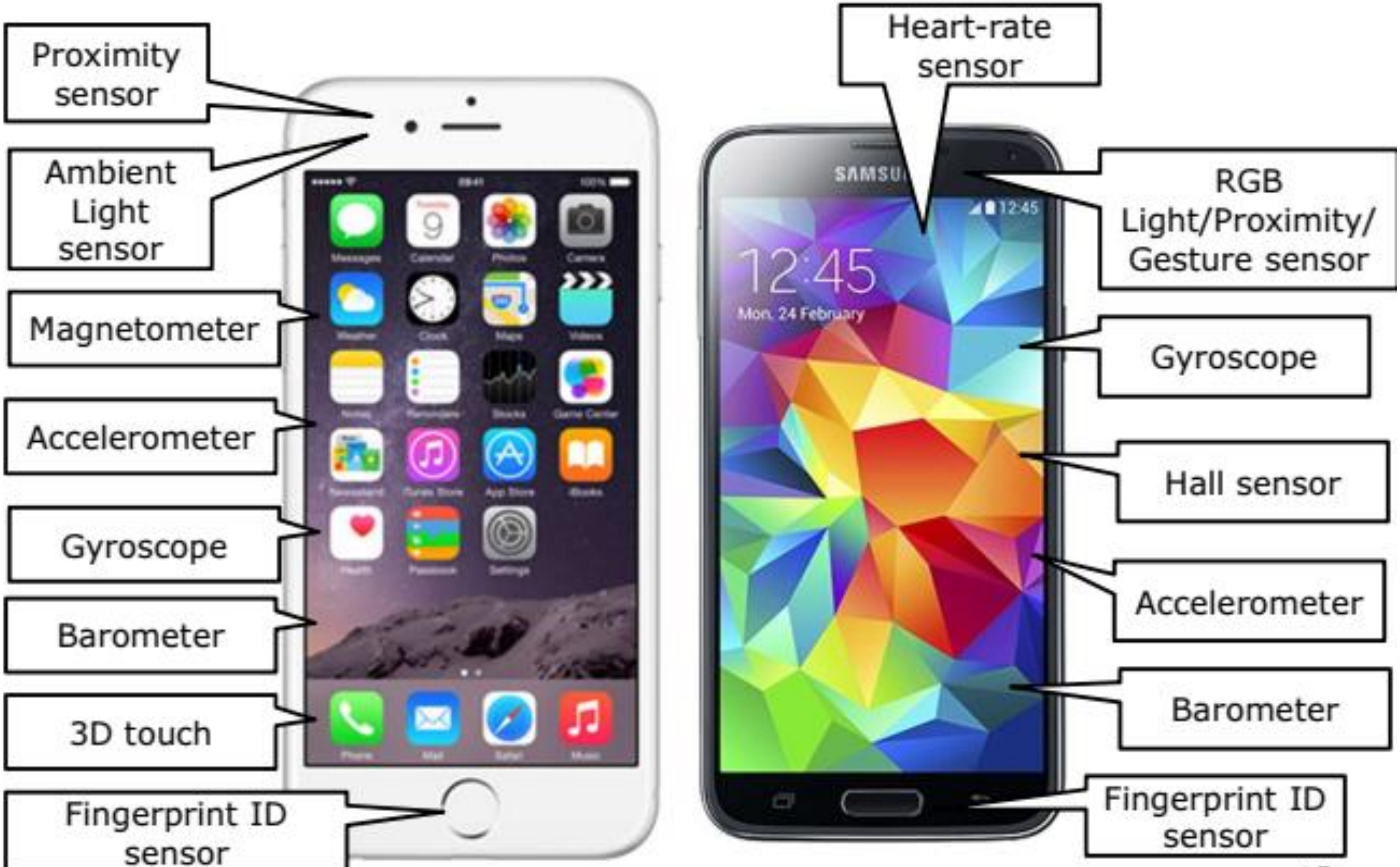
- Thermoelectric
  - A creation of voltage when there is a different temperature on each side of an object
  - For measurement of temperature

- Pyroelectric
  - A temporary voltage generated from a certain material when it is heated or cooled
  - For human/animal motion detection, flame detection, NDIR (Non Dispersive IR) gas analysis, etc.
  - Common in PIR (Passive InfraRed) sensors

Sensors Technologies: A Quick Overview

- Sound level
  - A generation of electrical voltage signals with vibration of air
  - Two popular approaches: inductive (dynamic microphone) and capacitive (condenser microphone)
  - Common sensing application: Sound meter
- Electromechanical sensors
  - Involving of mechanical devices.
  - Some examples:
    - Fluid flow measurement (e.g. mechanical flow meters), Microelectromechanical systems (e.g. MEMS gyroscopes), etc.
- Electrochemical sensors
  - Involving interaction between electricity and chemistry.
  - Some examples:
    - CO detector, pH meter, etc.

Sensors in Modern Smart Phones



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Thank You