SENSORS

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MEASUREMENT

An important subsystem, may be a mechanical or an electronic system

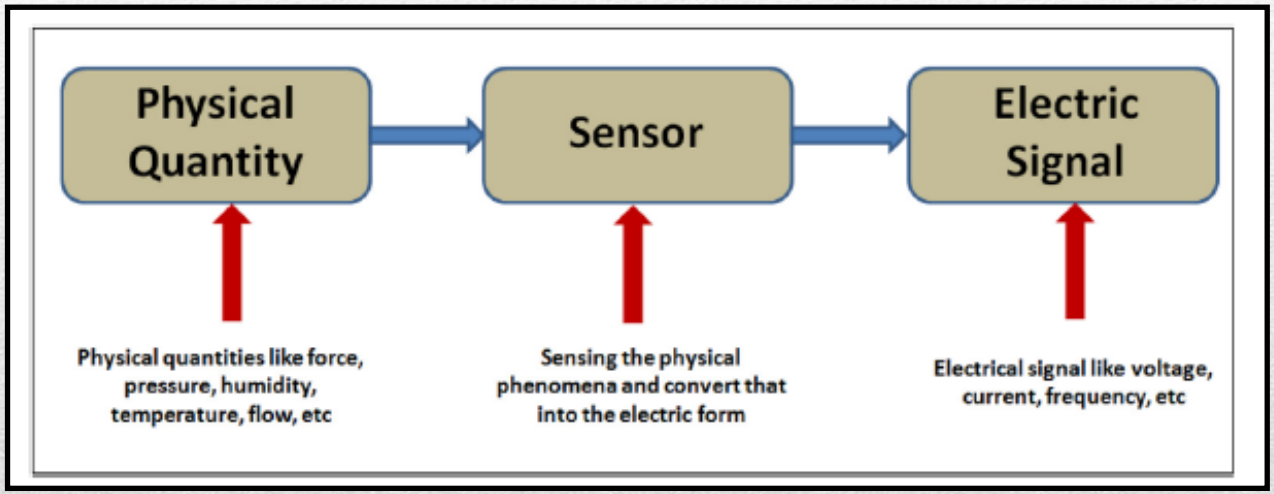
consists of sensors, actuators, transducers and signal processing devices.

used in the systems which perform specific tasks, to communicate with the real world

Communication → like reading the status of a signal from a switch or to trigger a particular output to light up an LED

SENSORS ??

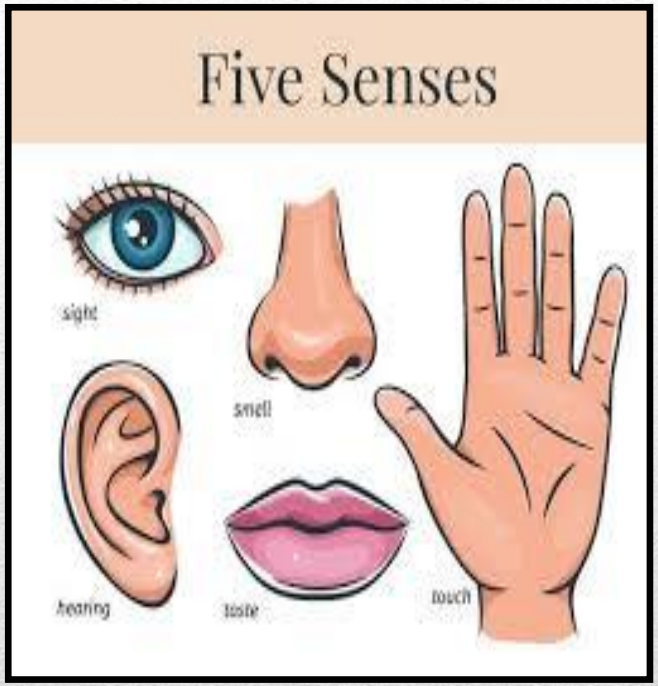
A device which provides a usable output in response to a specified measurand



Sensor: A physical quantity converts to a signal suitable for processing (e.g. optical, electrical, mechanical)

Active element of a sensor → Transducer

Sensors in Human Body???



- **Eyes take in light from the surroundings and relay that to nerve cells that send images to the brain.**
- **Ears take in sound waves from the air and vibrate, sending vibrations through the inner ear to hair cells that send signals to the brain.**
- **Particles inhaled into the nose and nerve cells contact the particles to send signals to the brain.**

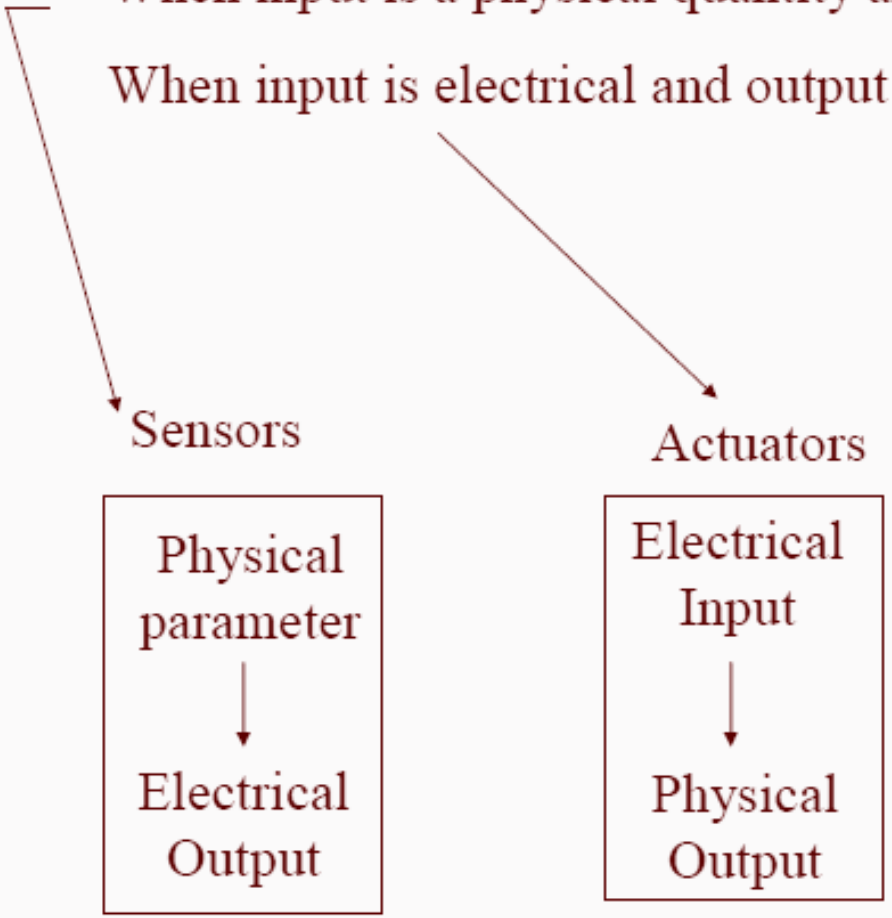
- **Sensors all over the skin are activated and send signals to the brain through the nervous system.**
- **Taste buds on the tongue are made of small cells that have little hairs that are activated by food particles; these hairs send signals through the nerves to the brain.**

Transducer?

A device which converts one form of energy to another

When input is a physical quantity and output electrical → Sensor

When input is electrical and output a physical quantity → Actuator



e.g. Piezoelectric:

Force -> voltage

Voltage-> Force

=> Ultrasound!

Microphone, Loud Speaker

Commonly Detectable Phenomena

- Biological
- Chemical
- Electric
- Electromagnetic
- Heat/Temperature
- Magnetic
- Mechanical motion (displacement, velocity, acceleration, etc.)
- Optical
- Radioactivity

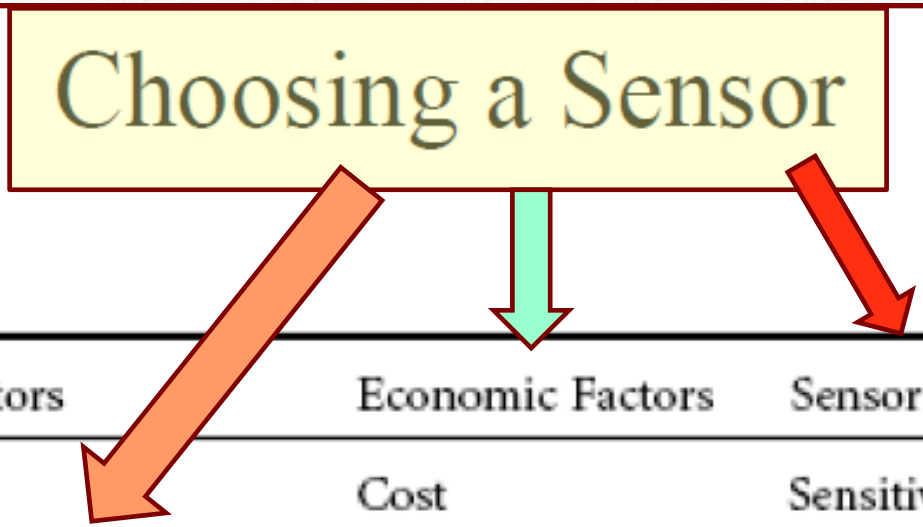
SENSORS BASED ON THEIR DETECTION PROPERTIES

Types	Properties
Thermal sensor	Temperature, heat, flow of heat etc
Electrical sensor	Resistance, current, voltage, inductance, etc
Magnetic sensor	Magnetic flux density, magnetic moment, etc
Optical sensor	Intensity of light, wavelength, polarization, etc
Chemical sensor	Composition, pH, concentration, etc
Pressure sensor	Pressure, force etc
Vibration sensor	Displacement, acceleration, velocity, etc
Rain/moisture sensor	Water, moisture, etc
Tilt sensors	Angle of inclination, etc
Speed sensor	Velocity, distance etc

Physical Principles: Examples

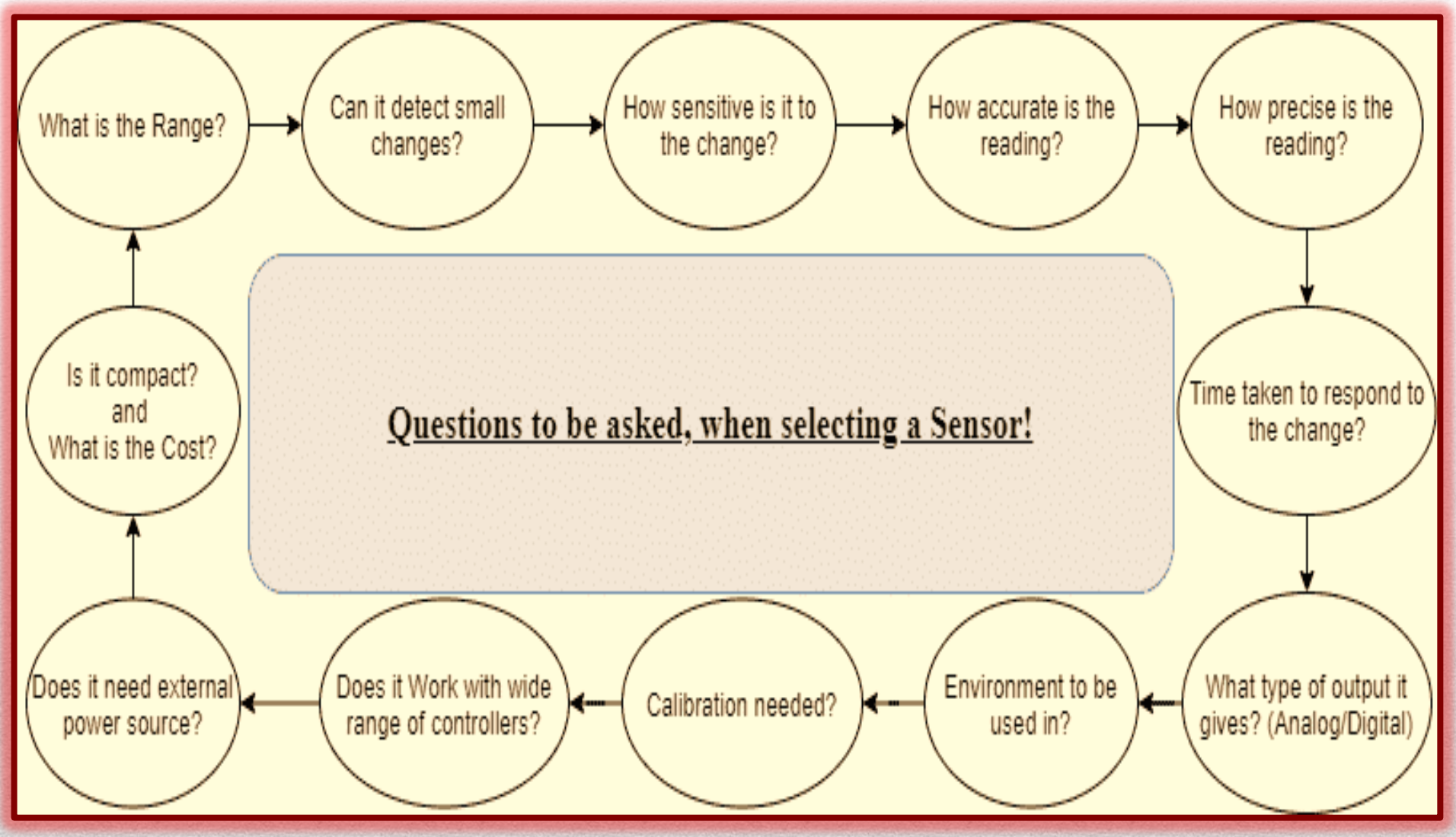
- **Amperes's Law**
  - A current carrying conductor in a magnetic field experiences a force (e.g. galvanometer)
- **Curie-Weiss Law**
  - There is a transition temperature at which ferromagnetic materials exhibit paramagnetic behavior
- **Faraday's Law of Induction**
  - A coil resist a change in magnetic field by generating an opposing voltage/current (e.g. transformer)
- **Photoconductive Effect**
  - When light strikes certain semiconductor materials, the resistance of the material decreases (e.g. photoresistor)

Choosing a Sensor

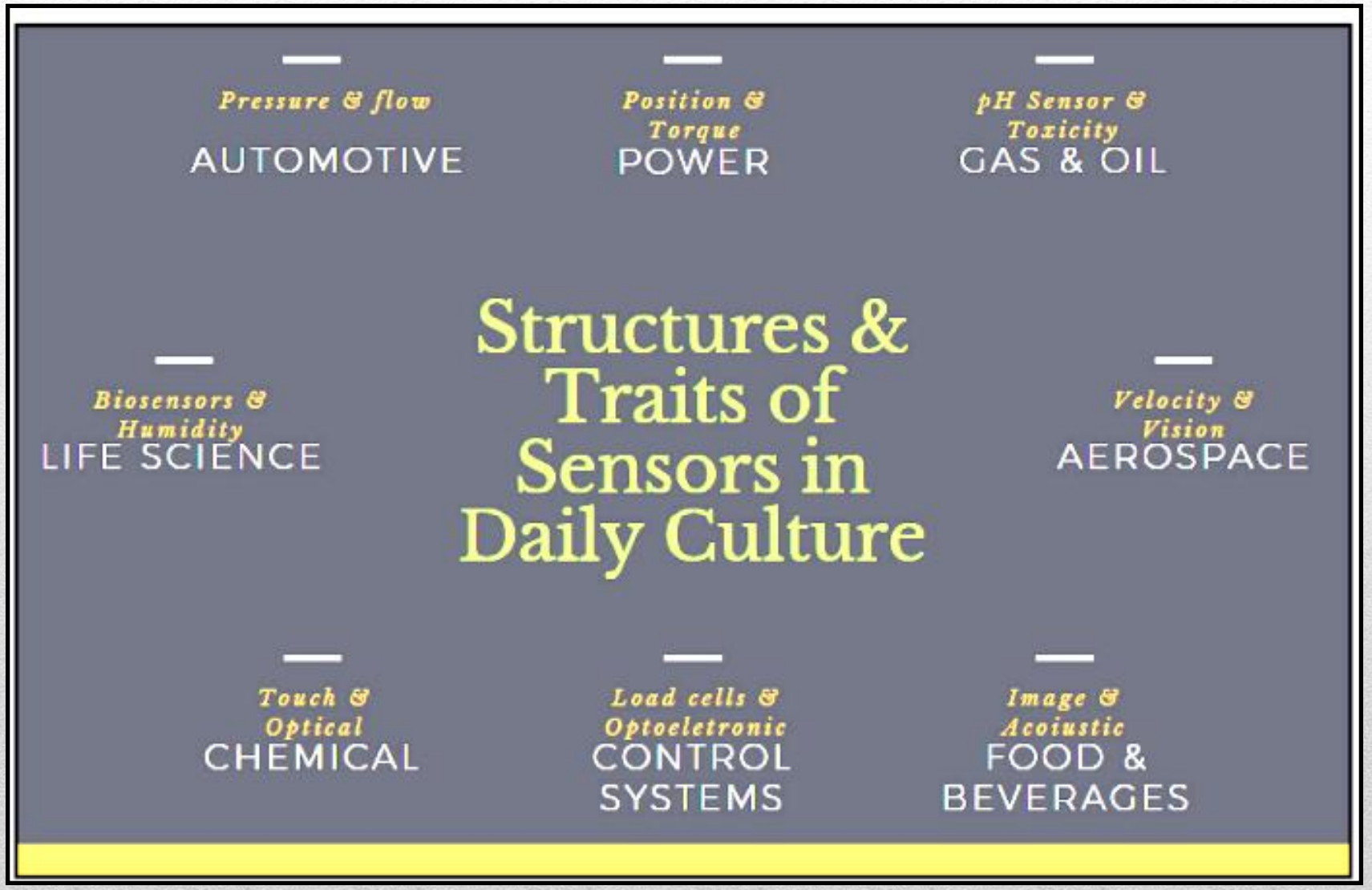


Environmental Factors	Economic Factors	Sensor Characteristics
Temperature range	Cost	Sensitivity
Humidity effects	Availability	Range
Corrosion	Lifetime	Stability
Size		Repeatability
Overrange protection		Linearity
Susceptibility to EM interferences		Error
Ruggedness		Response time
Power consumption		Frequency response
Self-test capability		

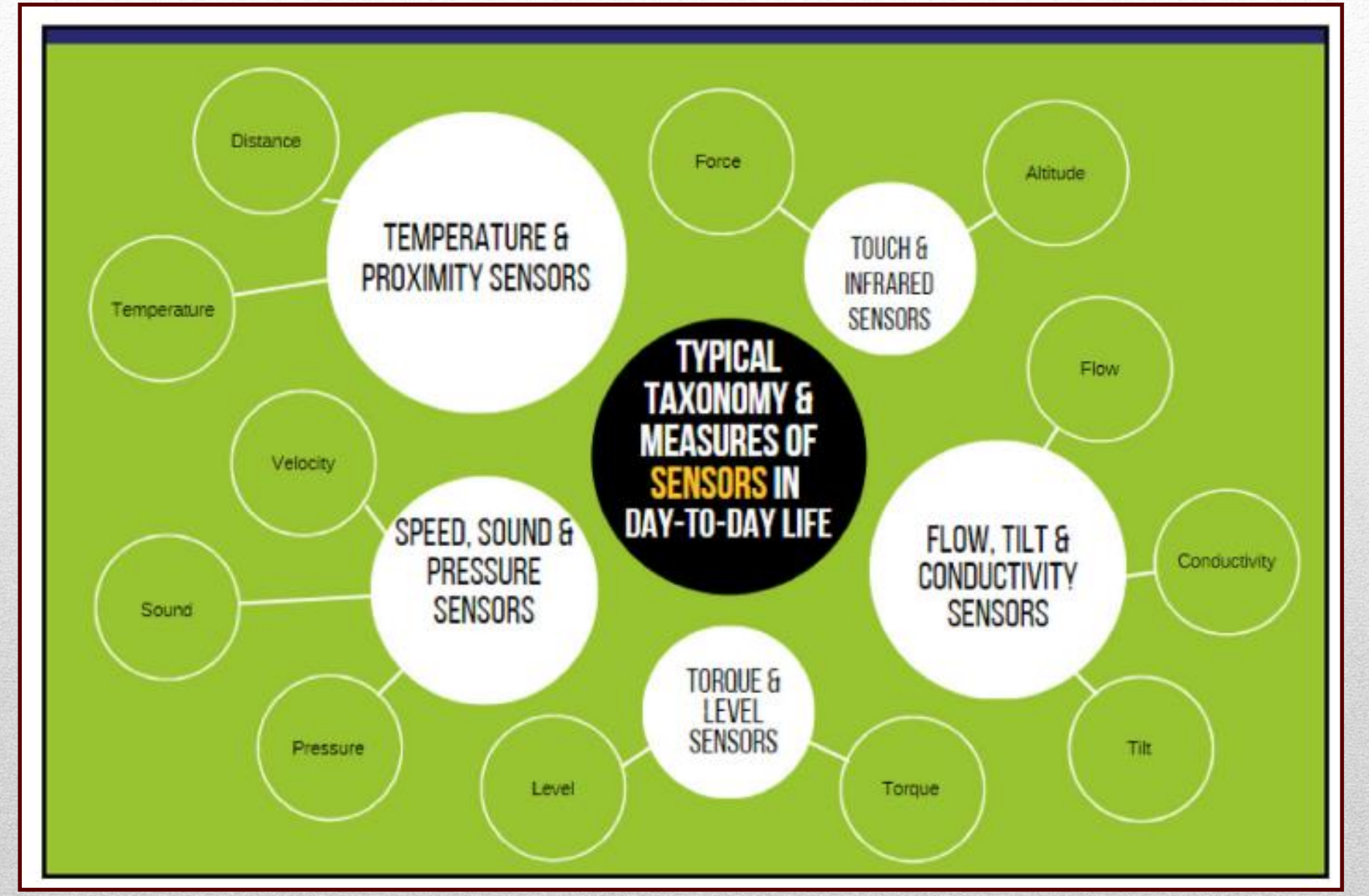
Selecting a sensor



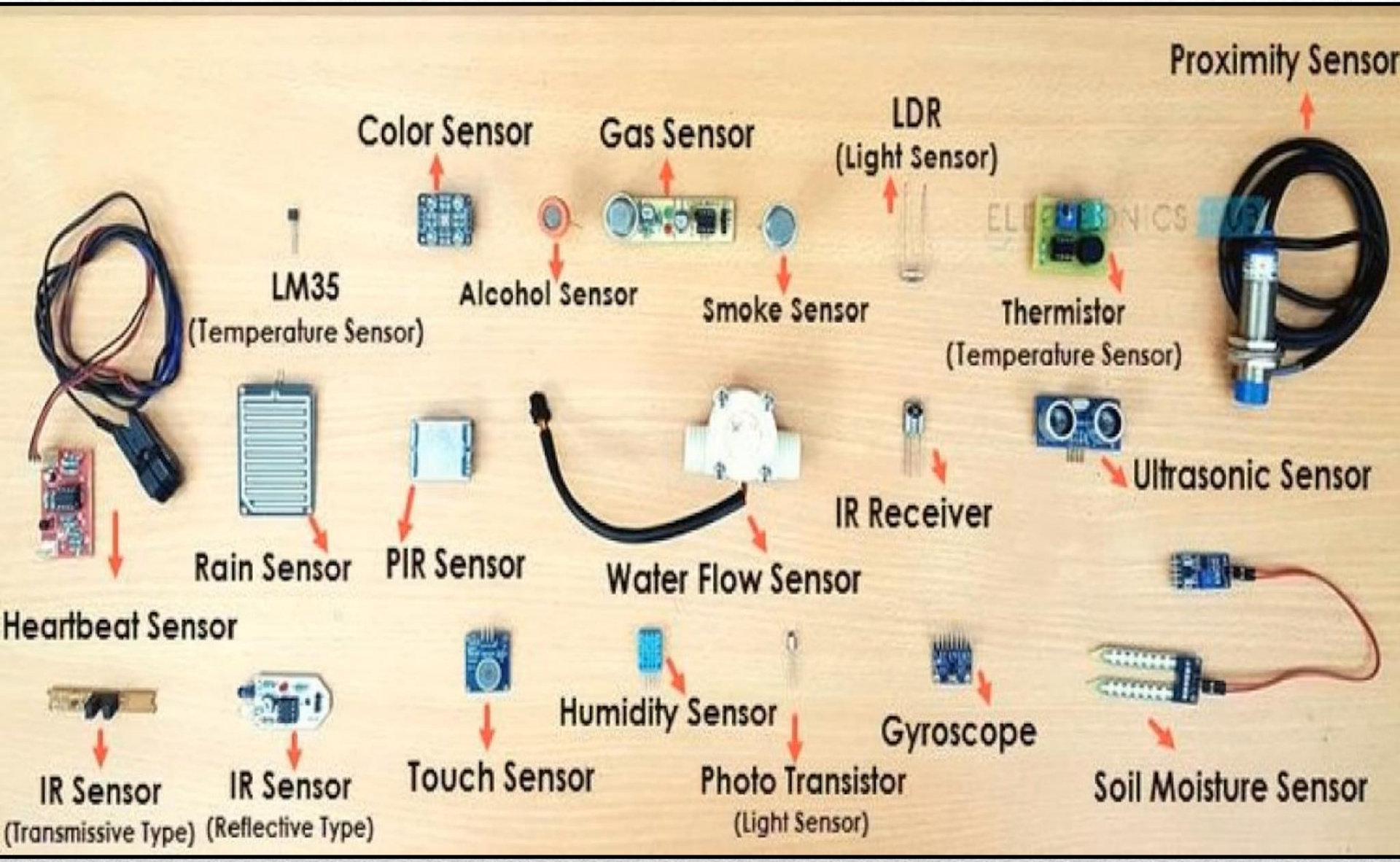
Several traits and typical market services of sensors.



Taxonomy and relevant measures of sensors



Types of Sensors



Need of Sensors

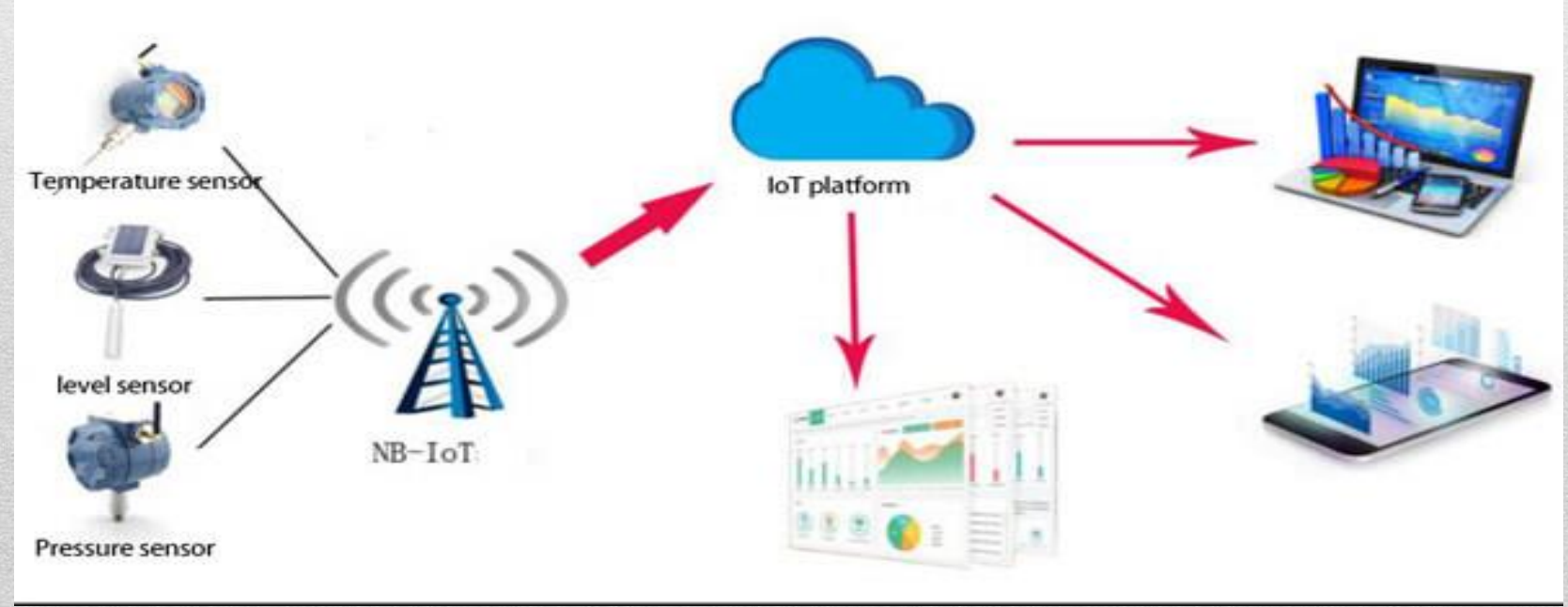
Sensors are pervasive. They are embedded in our bodies, automobiles, airplanes, cellular telephones, radios, chemical plants, industrial plants and countless other applications.

Without the use of sensors, there would be no automation !!

Sensors used in IoT's

What is things in IoT world ? Things that is sensors → gets connected in the Internet of Things → to sense and interact with the real world environment – from something as simple as a smoke detector to a robotic arm in manufacturing.

IoT system consists of: communication networks and connected devices. These devices mainly refer to sensors and actuators.



Classification of Sensors

1. Active & Passive Sensors
2. Contact & Non contact sensors
3. Relative & Absolute sensors
4. Analog & Digital sensors

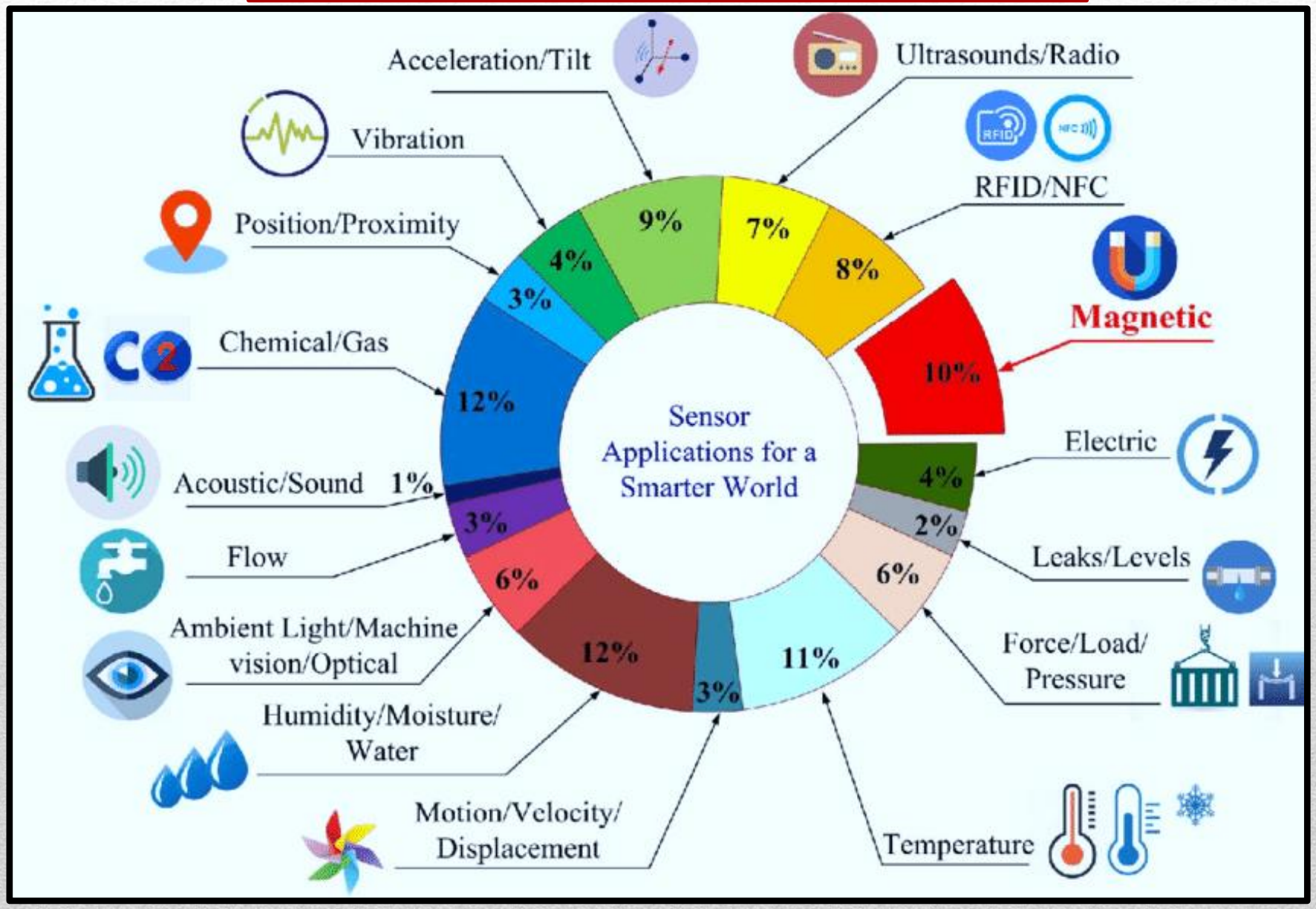
- **Active Sensors:** *requires a dedicated external power supply to function. like GPS and ultrasonic sensors.*
- **Passive sensors:** *doesn't require any external supply and can receive enough electrical signal from the environment like thermal sensors, NFC tags, etc.*

- **Contact sensors:** *requires physical contact with the environmental stimulus like touch sensors, temperature sensors, strain gauges.*
- **Non-contact** *sensors: do not require direct contact with the environmental stimulus like optical sensors, magnetic sensors, infrared thermometers.*

- **Absolute sensors:** *provides an absolute reading of the stimulus like thermistors.*
- **Relative sensors:** *provide measurements relative to something that is either fixed or variable like where the temperature difference is measured as opposed to direct measurement.*

- **Analog sensors:** *produces a continuous output signal proportional to the measurement. like thermometers, LDR, pressure sensors.*
- **Digital sensors:** *converts the measurement into a digital signal. like ultrasonic sensors, IR sensors.*

Top Sensors used in IoT



The following are examples of common IoT sensors that will be used:

- **Temperature sensors**
- **Pressure sensors**
- **Motion sensors**
- **Level sensors**
- **Image sensors**
- **Proximity sensors**
- **Water quality sensors**
- **Chemical sensors**
- **Gas sensors**
- **Smoke sensors**
- **Infrared (IR) sensors**
- **Acceleration sensors**
- **Gyroscopic sensors**
- **Humidity sensors**
- **Optical sensors**

Topics

5.2: Electro-optic sensors

- IR Sensors
- Image Sensors

5.3: Mechanical Sensors

- Pressure Sensors
- Motion Sensors

5.4: Environmental Sensor

- Temperature Sensors
- Humidity Sensors

Conclusion

- Sensors are everywhere.
- Process variables like temperature, pressure, level, flow rate, and turbidity are measured accurately.
- The electrical variables like the voltage, current, and frequency; mechanical variables like revolution, cycle number, positioning, the direction of movement, static and dynamic pressures, proximity; environmental variables, such as humidity, vibration, wind velocity, and direction are also measured by using these technologies.
- They are used for receiving information, data such as temperature, pressure, picture, etc.
- Sensors create a digital representation of the world in which they work by gathering data from houses, buildings, and vehicles. These can monitor and inform about the drug level in humans and detect any anomalies in the body. Sensors can assist in preventing symptoms and offering early warning of illness.