IOT SENSORS

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1 Sensors

Sensors are used for sensing things and devices etc. It is a device that provides a usable output in response to a specified measurement. The sensor reads a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical). The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance etc. Generally, sensors are used in the architecture of IOT devices.

2 Sensor Characteristics

A sensor can have two types of characteristics.

- Static Characteristic
- Dynamic Characteristic

2.1 Static Characteristic

It's about how the output of a sensor changes in response to an input change after steady state condition.

- **Accuracy :** It is the capability of measuring instruments to give a result close to the true value of the measured quantity. It measures errors. It is measured by absolute and relative errors. Express the correctness of the output compared to a higher prior system.

$$\text{Absolute error} = \text{Measured value} - \text{True value}$$
$$\text{Relative error} = \text{Measured value} \,/\, \text{True value}$$

- **Range :** It gives the highest and the lowest value of the physical quantity within which the sensor can actually sense. Beyond these values, there is no sense or no kind of response.
- **Resolution :** It is an important specification towards selection of sensors. The higher the resolution, better the precision. When the accretion is zero to, it is called threshold. It provide the smallest changes in the input that a sensor is able to sense.
- **Precision :** It is the capacity of a measuring instrument to give the same reading when repetitively measuring the same quantity under the same prescribed conditions. It implies agreement between successive readings, NOT closeness to the true value. It is related to the variance of a set of measurements. It is a necessary but not sufficient condition for accuracy.
- **Sensitivity :** It indicates the ratio of incremental change in the response of the system with respect to incremental change in input parameters. It can be found from the slope of the output characteristics curve of a sensor. It is the smallest amount of difference in quantity that will change the instrument's reading.
- **Linearity :** The deviation of the sensor value curve from a particular straight line. Linearity is determined by the calibration curve. The static calibration curve plots the output amplitude versus the input amplitude under static conditions.A curve's slope resemblance to a straight line describes the linearity.
- **Drift :** The difference in the measurement of the sensor from a specific reading when kept at that value for a long period of time.
- **Repeatability :** The deviation between measurements in a sequence under the same conditions. The measurements have to be made under a short enough time duration so as not to allow significant long-term drift.

2.2 Dynamic Characteristic

It depends on the properties of the system.

- **Zero-order system –** The output shows a response to the input signal with no delay. It does not include energy-storing elements.
  Ex. potentiometer measure, linear and rotary displacements
- **First-order system –** When the output approaches its final value gradually. It consists of an energy storage and dissipation element.
- **Second-order system –** Complex output response. The output response of the sensor oscillates before steady state.

3 Sensor Classification

Sensors are classified as:

- **Active Sensors :** It can not independently sense the input.
  Ex- Accelerometer, soil moisture, water level and temperature sensors.
- **Passive Sensors :** It independently sense the input. Example- Radar, sounder and laser altimeter sensors.
- **Analog Sensors :** The response or output of the sensor is some continuous function of its input parameter.
  Ex- Temperature sensor, LDR, analog pressure sensor.
- **Digital Sensors :** Its response in binary nature. It is designed to overcome the disadvantages of analog sensors. Along with the analog sensor, it also comprises extra electronics for bit conversion. Example – Passive infrared (PIR) sensor and digital temperature sensor.
- **Scalar Sensors:** It detects the input parameter only based on its magnitude. The answer for the sensor is a function of magnitude of some input parameter. It's Not affected by the direction of input parameters.
  Example – temperature, gas, strain, color and smoke sensor.
- **Vector Sensors :** The response of the sensor depends on the magnitude of the direction and orientation of input parameter.
  Example – Accelerometer, gyroscope, magnetic field and motion detector sensors.

4 Most used Sensors

- **Temperature Sensor :** Temperature sensors are used to measure the temperature of the ambient room. They come in different variants each working on different principles ideal for each use case, depending on the placement (indoor or outdoor), expected temperature range, temperature variations, size, etc
  Examples: Thermistors, thermocouples, RTD, mercury thermometers, pyrometers, etc
- **Pressure Sensor :** A pressure sensor senses the pressure applied ie, force per unit area, and it converts into an electrical signal. It has high importance in weather forecasting. There are various Pressure sensors available in the market for many purposes.
  For example, if there are any water leaks in the residential or commercial areas, a pressure sensor needs to be installed to check if there are any leaks and measures the pressure. All the smartphones, wearables have these barometric pressure sensors integrated into them.
- **Proximity Sensor :** A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. It often emits an electromagnetic field or a beam of electromagnetic radiation and looks for changes in the field or return signal.
  A most common application of this sensor is used in cars, when taking reverse, it detects the objects or obstacles and you will be alarmed.
  Inductive, Capacitive, Photoelectric, and Ultrasonic are the types of the proximity sensor.
- **Optical Sensors :** The Optical Sensors convert light rays into an electronic signal, it measures a physical quantity of light and transforms into a form which is readable, maybe digital form. Detects the electromagnetic energy and sends the results to the units. It involves no optical fibres. It is a great boon to the cameras on mobile phones. Also, it is used in mining, chemical factories, refineries, etc. LASER and LED are the two different types of the light source