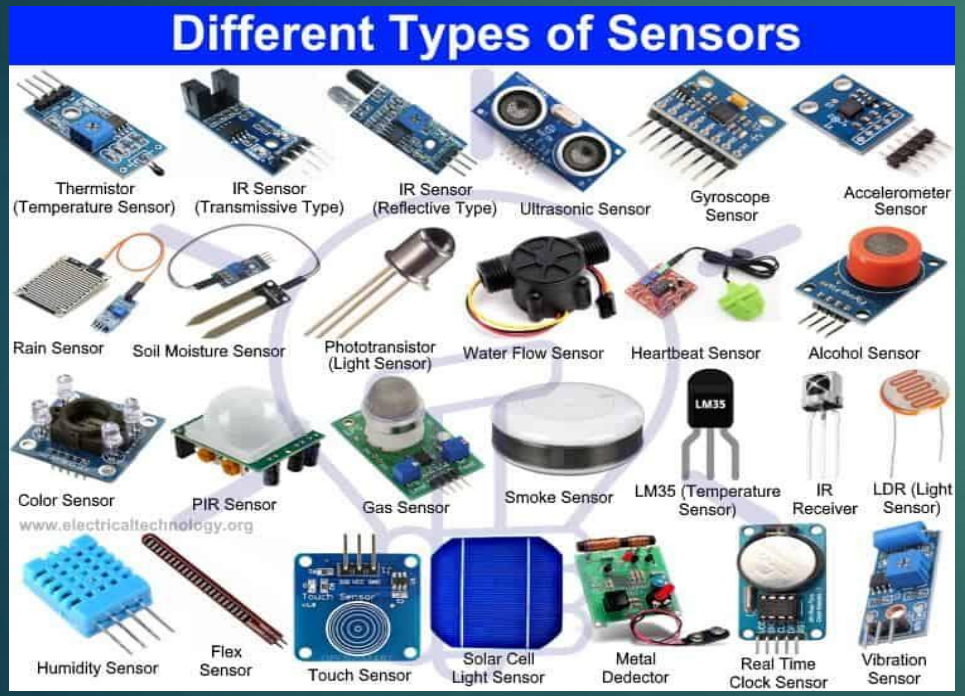
Sensors in Internet of Things(IoT)



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Sensors in IoT

A sensor in IoT is a device that detects and responds to changes in its environment. It is a key component of the Internet of Things (IoT), as it is responsible for collecting data from the physical world and converting it into digital signals that can be processed and transmitted by other IoT devices.

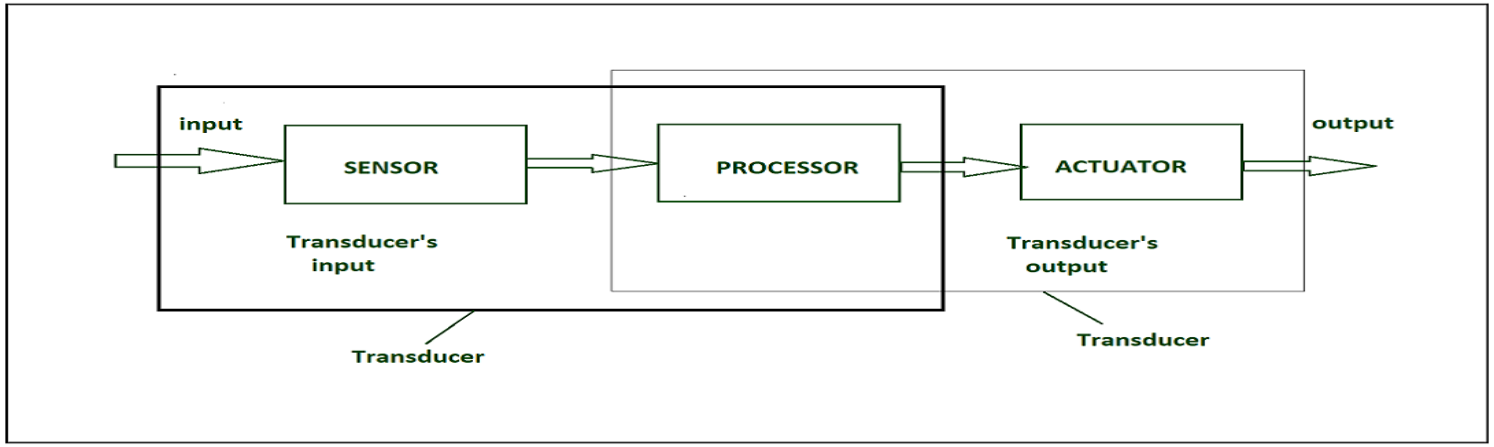
Sensors detect physical properties like temperature, pressure, light, motion, and more.

They consist of a sensing element that responds to the specific phenomenon being measured

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.

Classification of Sensors

- **Sensors can be classified into following categories:**
- Passive sensors
- Active sensors
- Analog sensors
- Digital sensors
- Scaler sensors
- Vector sensor



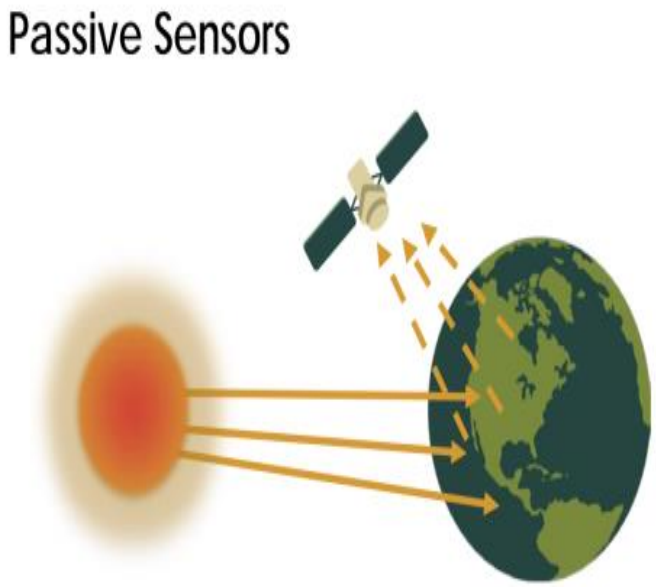
Passive Sensors

Passive Sensor

A passive sensor is a device that detects and responds to some type of input from the physical environment without emitting any energy of its own.

A passive sensor is a device that detects and responds to some type of input from the physical environment without emitting any energy of its own. They contrast with active sensors, which include transmitters that send out a signal, a light wavelength or electrons to be bounced off the target, with data gathered by the sensor upon their reflection.

Passive sensors don't need a dedicated power supply to function.



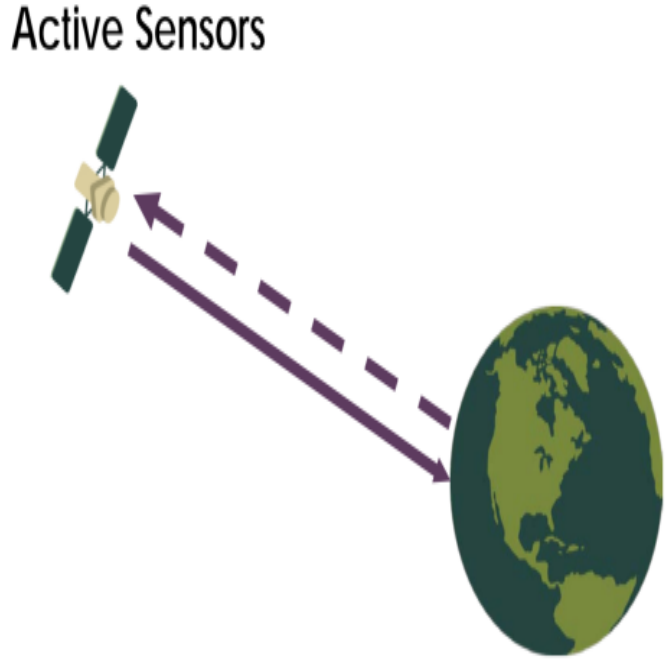
Active Sensors

Active sensors

An active sensor is a device that emits energy into its environment and then measures the response to that energy. This is in contrast to passive sensors, which only detect energy that is emitted by or reflected from the environment..

Active sensors are often used in applications where it is important to be able to detect objects or changes in the environment that are not easily visible to the naked eye. For example, active sensors are used in radar to detect aircraft and ships, in sonar to detect submarines, and in lidar to measure the distance to objects.

Passive sensors needs a dedicated power supply to function.



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Example

Camera

When we take a picture with the flash turned on, the camera **sends its own source of light**. After it illuminates the target, the camera captures the reflected light back to the camera lens.

So, cameras are ***active sensors*** when the **photographer uses flash**. It illuminates its target and measures the reflected energy back to the camera.

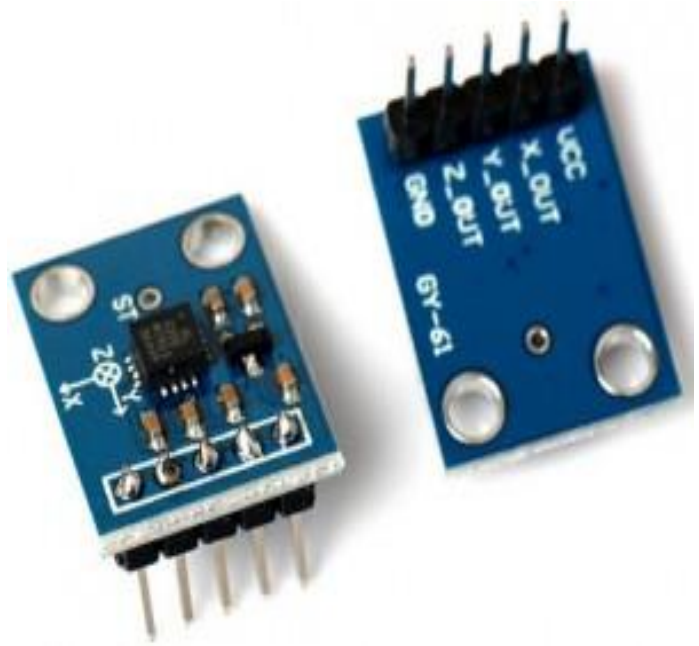
Cameras are ***passive sensors*** when the photographer does not use the flash. Because the camera is not sending the source of light, it uses naturally emitted light from the sun.

Analog Sensor

Analog Sensors measure the external parameters and give an analog voltage as an output. They produce a continuous output signal or voltage which is proportional to the quantity being measured

Or

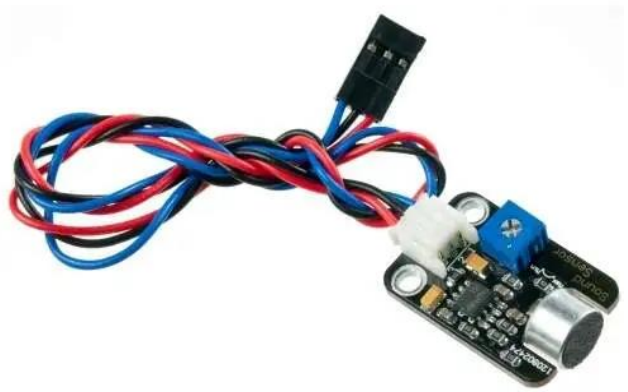
The response or output of the sensor is some continuous function of its input parameter. Ex- Temperature sensor, LDR, analog pressure sensor and analog hall effect.

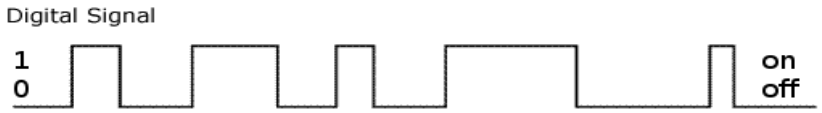


Digital Sensors

A digital sensor is a device that converts a physical quantity into a digital signal. This means that the output of the sensor is a series of numbers, rather than an analog signal. Digital sensors are often used in applications where it is important to be able to measure and transmit data accurately and reliably.

Digital sensors have a number of advantages over analog sensors. They are typically more accurate, reliable, and immune to noise. Additionally, digital sensors can be easily interfaced with electronic devices and can be transmitted over long distances without losing data.





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Scaler Sensors

A scalar sensor is a type of sensor that measures and provides data in the form of scalar quantities. Scalar quantities are mathematical quantities that have only magnitude and no direction

Examples of scalar sensor measurements include temperature, pressure, voltage, speed, and distance. These measurements are characterized solely by a numerical value and a unit of measurement, without any associated direction.

A scalar sensor is a sensor that measures a physical quantity that has only one dimension, such as temperature, pressure, or weight. The output of a scalar sensor is a single number.

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Vector Sensors

A vector sensor is a type of sensor that measures and provides data in the form of vector quantities. Vector quantities have both magnitude and direction. They require multiple pieces of information to fully describe them.

Examples of vector sensor measurements include acceleration, force, velocity, and displacement. These measurements involve both a numerical value, a unit of measurement, and a direction in space.

A vector sensor is a sensor that measures a physical quantity that has two or more dimensions, such as velocity, acceleration, or force. The output of a vector sensor is a set of numbers, one for each dimension of the quantity being measured.

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Characteristics of Sensors

Some important characteristics of sensors are as follows:

- **Sensitivity:** The sensitivity of a sensor is a measure of how much its output changes in response to a change in the input. A sensor with high sensitivity will produce a large change in output for a small change in input.
- **Resolution:** The resolution of a sensor is a measure of the smallest change in the input that can be detected by the sensor. A sensor with high resolution will be able to detect small changes in the input.
- **Accuracy:** The accuracy of a sensor is a measure of how close its output is to the true value of the input. A sensor with high accuracy will produce an output that is very close to the true value of the input.
- **Repeatability**: The repeatability of a sensor is a measure of how reproducible its output is when the same input is applied multiple times. A sensor with high repeatability will produce the same output every time the same input is applied.

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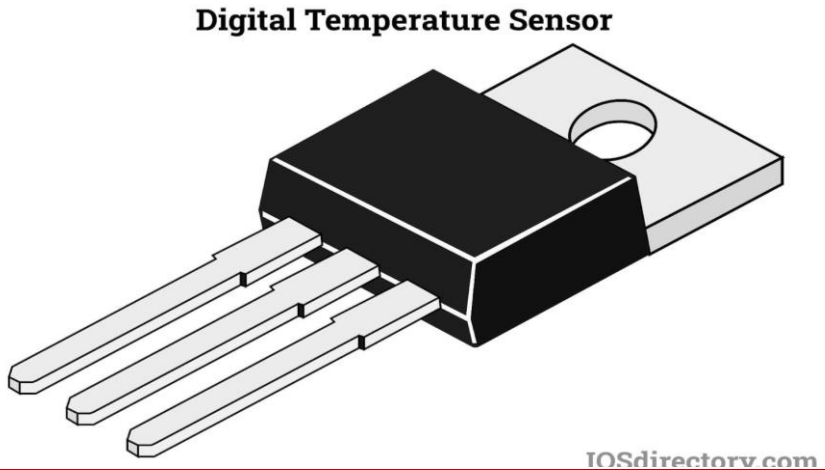
Characteristics of Sensors

- **Range:** The range of a sensor is the difference between the smallest and largest values of the input that the sensor can measure.
- **Linearity:** The linearity of a sensor is a measure of how well its output is proportional to the input. A sensor with high linearity will produce an output that is perfectly proportional to the input.
- **Hysteresis:** Hysteresis is the difference in output between a sensor when the input is increasing and when the input is decreasing. A sensor with high hysteresis will produce different outputs for the same input depending on whether the input is increasing or decreasing.
- **Noise:** Noise is any unwanted signal that is added to the output of a sensor. Noise can reduce the accuracy and repeatability of a sensor.

Examples

- **Temperature sensor**: A temperature sensor is used to measure the temperature of a substance. A common type of temperature sensor is a thermocouple, which consists of two wires made of different metals. When the temperature changes, the voltage between the wires changes. This voltage can be measured and converted into a temperature reading.

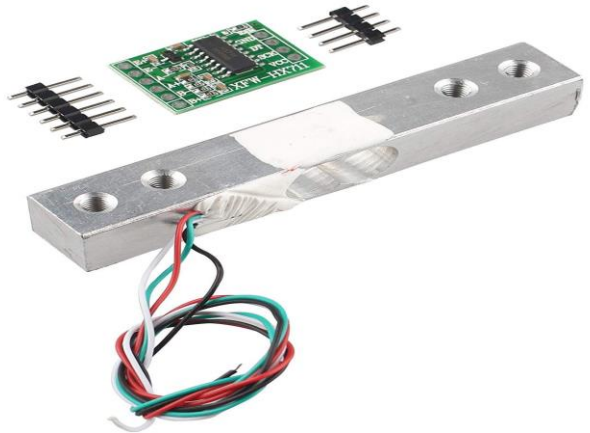


Examples

- **Pressure sensor:** A pressure sensor is used to measure the pressure of a gas or liquid. A common type of pressure sensor is a strain gauge, which is a thin metal strip that changes its resistance when it is stretched. The amount of stretching is proportional to the pressure, so the resistance change can be measured and converted into a pressure reading.

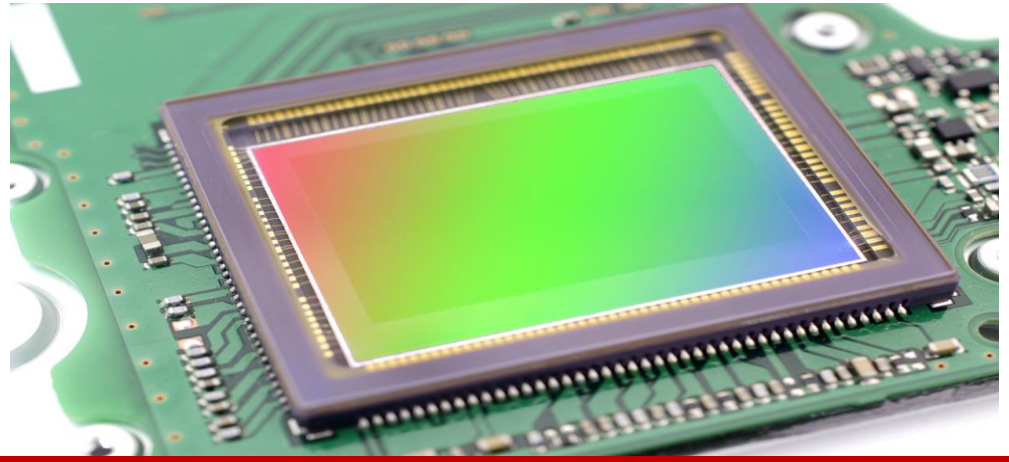
Examples

- **Weight sensor:** A weight sensor is used to measure the weight of an object. A common type of weight sensor is a load cell, which is a device that converts weight into an electrical signal. The load cell consists of a strain gauge, which is attached to a beam. When weight is applied to the beam, the strain gauge changes its resistance. This resistance change can be measured and converted into a weight reading.



Examples

- **Image sensor**: An image sensor is used to detect light and convert it into an electrical signal. A common type of image sensor is a CCD (charge-coupled device), which consists of an array of light-sensitive cells. When light hits a cell, it creates an electrical charge. The charges are then transferred to a readout register, where they can be measured and converted into an image.



Examples

- **Motion sensor:** A motion sensor is used to detect movement. A common type of motion sensor is an accelerometer, which measures the acceleration of an object. The acceleration can be used to detect movement, such as walking or running.

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Application of Sensors

- **Automotive Industry**:
  - **Proximity Sensors**: Used for parking assistance and collision avoidance.
  - **Oxygen Sensors**: Measure oxygen levels in exhaust gases for optimal engine performance.
- **Healthcare and Medical Devices**:
  - **Heart Rate Sensors**: Used in fitness trackers and medical monitoring devices.
  - **Blood Glucose Sensors**: Monitor blood sugar levels in diabetic patients.
- **Environmental Monitoring**:
  - **Air Quality Sensors**: Detect pollutants and particulate matter in the air.
  - **Weather Sensors**: Measure temperature, humidity, pressure, and wind speed for weather forecasting.
  - **Water Quality Sensors**: Monitor parameters like pH, dissolved oxygen, and contaminants in water bodies.

Application of Sensors

- **Industrial Automation**:
  - **Level Sensors**: Measure the level of liquids or solids in tanks or containers.
  - **Temperature Sensors**: Control and monitor temperature in industrial processes.
- **Home Automation**:
  - **Motion Sensors**: Trigger lighting or security systems in response to movement.
  - **Thermostats**: Control heating and cooling systems based on temperature readings.

Consumer Electronics:

- **Touch Sensors**: Enable touchscreens on smartphones and tablets.
- **Accelerometers and Gyroscopes**: Used for device orientation and motion sensing.
- **Light Sensors**: Adjust screen brightness based on ambient light conditions.

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Application of Sensors

- **Agriculture**:
  - **Soil Moisture Sensors**: Monitor soil moisture levels for efficient irrigation.
  - **Temperature and Humidity Sensors**: Assist in climate control for greenhouses.
  - **GPS Sensors**: Aid in precision agriculture by mapping field data.
- **Security and Surveillance**:
  - **Image Sensors**: Used in cameras for capturing visual information.
  - **Infrared Sensors**: Detect heat signatures for intrusion detection.
- **Transportation and Logistics**:
  - **GPS Sensors**: Provide real-time tracking and navigation.
  - **Load Cells**: Measure the weight of cargo in trucks and containers.


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