

Survey of sensors used in different fields

[Technology](#), [Information Technology](#)



This paper presents a survey of several major sensors used in different domains. It analyses several functional characteristics of sensors, such as Primary Input quantity (Measurand), Material and Application. We analysed various sensors used in different domains such as Agricultural, Medicine, Automobiles, Robotics, IoT, Mobile phones and Industrie. Finally we gave an overview of the considerations why these decisions are made.

Introduction

A sensor is an input device which provides an output (signal) with respect to a specific physical quantity (input). The term “input device” in the definition of a Sensor means that it is part of a bigger system which provides input to the main control system (like a Processor or a Microcontroller). Another unique definition of a Sensor is as follows: It is a device that converts signals from one energy domain to the electrical domain. The main purpose of a sensor is to detect events or changes in its environment. Sensors are majorly classified as Analog and Digital sensors. There are several classifications of sensors made by different experts. Some of them are Active, Passive, Electrical, Biological, Chemical, Radioactive sensors and so on.

Use of sensors in different domains

Sensors used in Agriculture

Agricultural sensors are mainly used in improving crop farming to help us feed the world. Hi-tech systems are in demand to help grow high-performance crops. Researchers are using sensors to match the crops to different soils and weather conditions. The various sensors used for the purpose of agriculture are Bio Sensor, Soil Moisture Sensor, PhotosynthesisSensor, Leaf area index Sensors.

Sensors used in Medicine

Electronic systems in medical equipment, devices and probes rely on sensor signals as a basis for control activities, accurate diagnosis and treatment.

Sensors play an ever more important role in medical technology with the aim of making medical devices even more effective and safer, while simplifying their operation. The various sensors used in this field are the Humidity sensor, Piezo-Film sensor, Position sensor, Temperature sensor, and the Pressure sensor.

Sensors used in Automobiles

The sensors built into the automobile engines is to ensure that the owner can identify and prevent possible issues before they result in breakdowns can result in expensive repairs. These automobile engine sensors also ensure that the vehicle is operating at its most efficient. The sensors used in the Automobile industry are Mass airflow sensors, Engine speed sensor, Oxygen sensors, Fuel Temperature sensor etc.

Sensors used in Robotics

There are hundreds of sensors used in the field of robotics to sense virtually anything you can think of, and it is almost impossible to list all available sensors. There are many other sensors used for specific applications. Robotic sensors are used to estimate a robot's condition and environment. These signals are passed to a controller to enable the appropriate behavior.

Sensors in robots are based on the functions of human sensory organs.

Robots require extensive information about their environment in order to function effectively. The different available sensors are Light sensors, Sound sensors, Temperature Sensor, ContactSensor, Proximity sensor, Distance sensors, Pressure sensor, Tilt sensor, Navigation /Position sensor, Gyroscope, the Voltage sensor, IMU and Current sensor.

Sensors used in IOT

Industries and organizations have been using various kind of sensors for a long time but the intent of The internet of things has taken the role of sensors and evolutions of sensors to a completely different level. IoT platforms function and deliver valorous kind of intelligence and data using a variety of sensors. They serve to collect data, pushing it and sharing it with a whole network of connected devices. All this collected data makes it possible for devices to autonomously function, and the whole ecosystem is becoming “ smarter” every day. By combining a set of sensors and a communication network, devices share information with one another and are improving their effectiveness and functionality. The sensors used are the Temperature sensor, Pressure sensor, Gas sensor, Smoke sensor, IR sensor, Level sensor, an Image sensor, Motion detection sensors, Accelerometer sensor, Gyroscope sensor, Humidity sensor, and Optical sensor.

Comparison

Sensors in the field of agriculture

Primary input quantity: Biosensors are analytical devices that convert a biological response into an electrical signal. Soil moisture sensors measure the volumetric content of water in the soil. Photosynthesis fuses the primary sensor signals measuring temperature, relative humidity, solar radiation, carbon dioxide, air pressure, and air flow and uses these measurements to calculate net photosynthesis. Leaf area index sensor gets digital photos of plant canopies and transfers them to the data server.

Material: Biosensors are made up of electrically conductive compositions including silver and carbon for lines and contact pads and polymers and copolymers. Soil moisture sensors are made from materials that are porous to water i. e. ceramic, tough butyrate plastic. Photosynthesis sensor uses several sensors integrated into an FPGA. Leaf area index sensors have a camera sensor, GPS module, memory, solar panel and also a software component that integrates the digital input from the hardware components.

Properties: Biosensors are highly specific, economical and compatible. Soil moisture provides high absolute accuracy, is stable in high temperature and salinity and provides less disturbance to the soil. Photosynthesis is highly accurate and precise, economical and provides stable results. Leaf area index sensor is Portable, light-weight, Easy-to-use with data displayed on the screen or in data logger and is ideal for scientific researchers, growers, and consultants.

Sensors used in Medicine

Primary Input quantity: Humidity sensor measures the water vapour content by picking up the changes in the resistance value of sensor element. In Piezo Film sensor the input is stress applied to tiny, interlocking crystal domain which has both positive and negative charges. Position sensor takes AC reference voltage (2-20 Vrms, 2-20kHz) as input which is applied to the winding.

Materials: A humidity sensor is made up of a thin thermostat polymer film based capacitive RH Sensor and is fabricated on a silicon substrate. Piezo film sensor is made from polyvinylidene fluoride which possesses

piezoelectric properties. Position sensor consists of a movable soft-iron ferromagnetic core which moves up and down inside the tubular body of LVDT.

Properties: Humidity sensor Suitable for high-temperature environments and high corrosive situations, very durable, Higher resolution compared to other types. Piezo film sensor has High dielectric strength, High elastic compliance, Wide frequency range, High impact resistance, High mechanical strength and stability. Position sensors have good resolution, accuracy, repeatability and are very expensive.

Sensors used in Automobiles

Primary input quantity: Mass air flow sensor measures the amount of air the engine takes in (engine load). The engine speed sensor is meant to assess the speed at which the crankshaft spins. Oxygen sensor measures the amount of unburnt oxygen level that is present in the exhaust pipe. Fuel temperature sensor measures the temperature of the fuel.

Materials: The intake manifolds in mass air flow sensor are made of cast iron, aluminum, composite plastic and tungsten steel needed for its ability to sense the changes in air current and density. Air filters are either paper or foam. The main active component in most of the Oxygen sensors is Zirconium Dioxide Zirconium dioxide, ZrO_2 . This ceramic material is housed in gas permeable electrodes of platinum permeable electrodes of platinum. Fuel temperature sensor is a semiconductor sensor fabricated upon thin silicon wafers.

Properties: Mass air flow sensor is highly resistive to temperature, computer controlled sensor and provides accurate results. Oxygen sensors have a good response time, reproducibility of emf, thermal shock resistance. Engine speed sensors are very reliable in harsh speed sensing environments that require shock-proof sensors.

Sensors used in Robotics

Primary input quantity: The most commonly used light sensors in robotics are photoresistors and photovoltaic cells. The input to the photoresistor is light. The resistance of a photoresistor decreases with increasing incident light intensity. The input to the photovoltaic cell is solar radiation which is converted into electrical energy. The commonly used sound sensor is Microphone sensor which detects a sound and processes an output signal voltage. The temperature sensor like LM35 has a voltage of +5V to the input pin, which can measure temperate in the form of voltage. Contact sensors are nothing but a push button switch or a limit switch which has a voltage input and the difference between the voltages is calculated. There are three types of proximity sensors-IR Transceiver, Ultrasonic Sensor and Photoresistor. The input to the IR Transceiver is the reflected IR light beam. The input to the Ultrasonic sensor is the echo signals from the object. The input to the photoresistor is the number of light changes which in turn changes the resistance. Some of the distance sensors used are Ultrasonic distance sensor, IR transceiver, laser range sensor, and encoders. The input to the laser range sensor if the reflected laser light. The input to the encoder is the rotation of the disk which interrupts the emitted light and generates a signal output. The input to the stereo camera is an image. Tilt sensor

contains a metallic ball inside that will commute the two pins of the device from on to off and vice versa if the sensor reaches a certain angle. The most commonly used navigation sensor is a GPS sensor. The input to the GPS sensor is the signals from Satellites orbiting around the earth. The input to the accelerometers is the acceleration forces (static and dynamic forces) which changes the capacitance between the internal capacitive plates. From these changes in capacitance, the acceleration can be determined. It mainly depends on the Earth's gravity. The input to the gyroscope is rotational velocity about some (x, y, z) axis. The input to the IMU unit is the changes in an objects orientation, velocity and gravitational forces. The input to the voltage sensor is a low voltage which is then amplified. The input to the current sensor is the current flow in a circuit.

Materials: Photoresistors are made of high resistance semiconductors such as silicon or germanium, cadmium sulfide or cadmium selenide. A photovoltaic cell is made of silicon (single-crystalline, multi-crystalline and amorphous), polycrystalline thin films such as copper indium diselenide, cadmium telluride, and gallium arsenide. Microphone sensor is made of Permanent magnets which are generally made from a neodymium iron boron compound. The voice coil and cable are made from copper wire. Plastic is used for cable insulation. The case is usually made from aluminium sheet and sometimes plastic. LM35 is made of semiconductor for IC base and metal for terminals in the IC. Push button switch or a limit switch Buttons are typically made out of hard material, usually plastic or metal.

IR Transceiver is made of gallium nitride (GaN), cesium nitrate (CsNO₃), polyvinyl fluorides, derivatives of phenylpyridine, and cobalt phthalocyanine. Ultrasonic Sensor is made of piezoelectric material, Metallic Net, Resonator & Vibrator, Unimorph Disc. Encoders are made of housing, interrupter disk, and light source, sensing element and support components. GPS sensor is made of satellites, ground stations, and receivers. Accelerometers capacitive, minuscule springs, piezoelectric materials. The gyroscope is made of a motor, metal gimbals, axle and gimbal ring using Aluminium and titanium. The voltage sensor is made of resistors, sensing wires, coils, magnet spring, capacitor. The current sensor is made of monocrystalline, amorphous and permalloy materials.

Properties: Photoresistors are wavelength dependent, sensitive and have high latency photovoltaic cells. Microphone sensor's flexibility is extremely good and the signal is therefore of extremely good quality. LM35 has a low current of less than 60 uA, having low self-heating (low-heating) of less than 0.1 °C in still air, has a low output impedance is 0.1 W for 1 mA load, have nonlinearities only about $\pm \frac{1}{4}$ °C. IR Transceiver is very sensitive to temperature, need only less power, portable. Ultrasonic Sensor has very high speed and produces vibrations in low viscosity liquids. Encoders low latency and no motion compensation. Accelerometers have high impedance, minimize susceptibility to external noise and are sensitive in nature. GPS compact and rugged design for applications with minimal space. The gyroscope has two basic properties-rigidity and precession.

Sensors used in IoT

Primary input quantity: A temperature sensor is thermally sensitive resistors whose prime function is to exhibit a large, predictable and precise change in electrical resistance when subjected to a corresponding change in body temperature. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. Gas sensors are devices that can detect the presence and concentration of various hazardous gases and vapors, such as toxic or explosive gases, volatile organic compounds (VOCs), humidity, and odors. An infrared sensor is an electronic instrument that is used to sense certain characteristics by either emitting or detecting infrared radiation. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. An image sensor is an electronic device that converts an optical image into an electronic signal. It is used in digital cameras. Motion detectors detect emitted infrared energy – given off by humans and animals in the form of heat. An accelerometer is an electromechanical device used to measure acceleration forces. Such forces may be static, like the continuous force of gravity or, as is the case with many mobile devices, dynamic to sense movement or vibrations. A level sensor is a device for determining the level or amount of fluids, liquids or other substances that flow in an open or closed system.

Materials: The materials used in temperature sensors are iron, nickel chromium/nickel aluminum, nicrosil/ nisil, copper constantan and so on.

Pressure sensors made of Inconel X, phosphor bronze, beryllium copper or stainless steel are the most corrosion resistant materials to be used in the sensor. Tin dioxide (SnO₂) is the commonly used gas sensing material. A few

detector materials using which in infrared sensors are Mercury cadmium telluride (MCT), Indium antimonide, Indium arsenide, Lead selenide, QWIP, QDIP, Lithium tantalate (LiTaO₃), Triglycinesulfate (TGS). Crystalline silicon is the material used to make photodetectors in standard CMOS and CCD image sensors. Materials commonly used in motion detector sensors include gallium nitride (GaN), caesium nitrate (CsNO₃), polyvinyl fluorides, derivatives of phenylpyridine, and cobalt phthalocyanine. Piezoelectric materials used for the purpose of accelerometers fall into two categories: single crystal and ceramic materials. The first and more widely used are single-crystal materials (usually quartz).

Properties: The Temperature sensor is durable, linear, highly-sensitive, has low reactivity, low response time etc. The pressure sensor has minimal deformation, electronic pressure measurement instruments have excellent dynamic characteristics and low material strain resulting in high resistance to alternating loads and long-term durability. The gas sensor has characteristics such as sensitivity, selectivity, time response, stability, durability, reproducibility, and reversibility. Infrared sensors are very sensitive to temperature; need only less power, portable etc. Image sensors have no sensor noise, infinite dynamic range, high spectral responsivity, infinite high frame rate, an infinite number of pixels, zero energy consumption and low manufacturing cost. Motion detectors have good detection performance, noise resistance, causes of false detection, cost performance and are have a highly sensitive quad element. Accelerometers have high impedance, minimize susceptibility to external noise and are sensitive in nature.

Conclusion

The market for sensors used in the process industries is growing steadily.

Smart sensors and sensors with digital communication features are replacing traditional sensors more and more. Wireless sensors, too, are on the rise, especially in auxiliary plants. Process sensors contribute to enhancing plant productivity, availability and safety, and they will grow in importance.

Advances in material science and engineering have paved the way for the development of new and more capable sensors. It enables a multidisciplinary approach for identifying opportunities and making realistic assessments of technical risk and could be used in relevant research and development.