SENSOR

Definition

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Basics

A **sensor** is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a mercury thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube.

There are a lot of different types of sensors. Sensors are used in everyday objects.

A **Thermal sensors** is a sensor that detects temperature. Thermal sensors are found in many laptops and computers in order to sound an alarm when a certain temperature has been exceeded.

- temperature sensors: thermometers
- heat sensors: bolometer, calorimeter

An **electromagnetic sensor** is an electronic device used to measure a physical quantity such as pressure or loudness and convert it into an electronic signal of some kind (e.g a voltage).

- electrical resistance sensors: ohmmeter
- electrical voltage sensors: voltmeter
- electrical power sensors: watt-hour meter
- magnetism sensors: magnetic compass
- metal detectors
- Radar

Mechanical sensors:

- Pressure sensors: barometer
- Vibration and shock sensors

A <="" b="">detects physical movement in a given area.

- radar gun, tachometer

Car sensors:

- reversing sensor

- rain sensor

Because of certain disadvantages of physical contact sensors, newer technology non-contact sensors have become prevalent in industry, performing well in many applications. The recent style of non-contact sensors shows that “Thin(g) is In”. Market trends show that form and size are important. Users are looking for smaller and more accurate sensors. New technologies for the sensing chips are breaking application barriers. For the future, the trend will be to continue to provide smaller, more affordable sensors that have the flexbility to fit even more applications in both industrial and commercial environments.

Topics of Interest

A **sensor** is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a mercury-in-glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, all sensors need to be calibrated against known standards.

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics.

A sensor is a device which receives and responds to a signal or stimulus.Here,the term "stimulus" means a property or a quantity that needs to be converted into electrical form.Hence,sensor can be defined as a device which receives a signal and converts it into electrical form which can be further used for electronic devices.A sensor differs from a transducer in the way that a transducer converts one form of energy into other form whereas a sensor converts the received signal into electrical form only.

A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C. Sensors that measure very small changes must have very high sensitivities. Sensors also have an impact on what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors need to be designed to have a small effect on what is measured, making the sensor smaller often improves this and may introduce other advantages. Technological progress allows more and more sensors to be manufactured on a microscopic scale as microsensors using MEMS technology. In most cases, a microsensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches.

Classification of measurement errors

A good sensor obeys the following rules:

- Is sensitive to the measured property
- Is insensitive to any other property

- Does not influence the measured property

Ideal sensors are designed to be linear. The output signal of such a sensor is linearly proportional to the value of the measured property. The sensitivity is then defined as the ratio between output signal and measured property. For example, if a sensor measures temperature and has a voltage output, the sensitivity is a constant with the unit [V/K]; this sensor is linear because the ratio is constant at all points of measurement.

Sensor deviations

If the sensor is not ideal, several types of deviations can be observed:

- The sensitivity may in practice differ from the value specified. This is called a sensitivity error, but the sensor is still linear.
- Since the range of the output signal is always limited, the output signal will eventually reach a minimum or maximum when the measured property exceeds the limits. The full scale range defines the maximum and minimum values of the measured property.
- If the output signal is not zero when the measured property is zero, the sensor has an offset or bias. This is defined as the output of the sensor at zero input.
- If the sensitivity is not constant over the range of the sensor, this is called nonlinearity. Usually this is defined by the amount the output differs from ideal behavior over the full range of the sensor, often noted as a percentage of the full range.
- If the deviation is caused by a rapid change of the measured property over time, there is a dynamic error. Often, this behaviour is described with a bode plot showing sensitivity error and phase shift as function of the frequency of a periodic input signal.
- If the output signal slowly changes independent of the measured property, this is defined as drift (telecommunication).
- Long term drift usually indicates a slow degradation of sensor properties over a long period of time.
- Noise is a random deviation of the signal that varies in time.
- Hysteresis is an error caused by when the measured property reverses direction, but there is some finite lag in time for the sensor to respond, creating a different offset error in one direction than in the other.
- If the sensor has a digital output, the output is essentially an approximation of the measured property. The approximation error is also called digitization error.
- If the signal is monitored digitally, limitation of the sampling frequency also can cause a dynamic error.
- The sensor may to some extent be sensitive to properties other than the property being measured. For example, most sensors are influenced by the temperature of their environment.

All these deviations can be classified as systematic errors or random errors. Systematic errors can sometimes be compensated for by means of some kind of calibration strategy. Noise is a random error that can be reduced by signal processing, such as filtering, usually at the expense of the dynamic behaviour of the sensor.

The **resolution** of a sensor is the smallest change it can detect in the quantity that it is measuring. Often in a digital display, the least significant digit will fluctuate, indicating that changes of that magnitude are only just resolved. The resolution is related to the precision with which the measurement is made. For example, a scanning tunneling probe (a fine tip near a surface collects an electron tunnelling current) can resolve atoms and molecules.

Types

Because sensors are a type of transducer, they change one form of energy into another. For this reason, sensors can be classified according to the type of energy transfer that they detect.

Thermal

- temperature sensors: thermometers, thermocouples, temperature sensitive resistors (thermistors and resistance temperature detectors), bi-metal thermometers and thermostats
- heat sensors: bolometer, calorimeter

Electromagnetic

- electrical resistance sensors: ohmmeter, multimeter
- electrical current sensors: galvanometer, ammeter
- electrical voltage sensors: leaf electroscope, voltmeter
- electrical power sensors: watt-hour meters
- magnetism sensors: magnetic compass, fluxgate compass, magnetometer, Hall effect device
- metal detectors RADAR

Mechanical

- pressure sensors: altimeter, barometer, barograph, pressure gauge, air speed indicator, rate-of-climb indicator, variometer
- gas and liquid flow sensors: flow sensor, anemometer, flow meter, gas meter, water meter, mass flow sensor
- gas and liquid viscosity and density: viscometer, hydrometer, oscillating U-tube
- mechanical sensors: acceleration sensor, position sensor, selsyn, switch, strain gauge
- humidity sensors: hygrometer

Chemical

- Chemical proportion sensors: oxygen sensors, ion-selective electrodes, pH glass electrodes, redox electrodes, and carbon monoxide detectors.

Optical radiation

- light time-of-flight. Used in modern surveying equipment, a short pulse of light is emitted and returned by a retroreflector. The return time of the pulse is proportional to the distance and is related to atmospheric density in a predictable way - see LIDAR.

- light sensors, or photodetectors, including semiconductor devices such as photocells, photodiodes, phototransistors, CCDs, and Image sensors; vacuum tube devices like photo-electric tubes, photomultiplier tubes; and mechanical instruments such as the Nichols radiometer.
- infra-red sensor, especially used as occupancy sensor for lighting and environmental controls.
- proximity sensor- A type of distance sensor but less sophisticated. Only detects a specific proximity. May be optical - combination of a photocell and LED or laser. Applications in cell phones, paper detector in photocopiers, auto power standby/shutdown mode in notebooks and other devices. May employ a magnet and a Hall effect device.
- scanning laser- A narrow beam of laser light is scanned over the scene by a mirror. A photocell sensor located at an offset responds when the beam is reflected from an object to the sensor, whence the distance is calculated by triangulation.
- focus. A large aperture lens may be focused by a servo system. The distance to an in-focus scene element may be determined by the lens setting.
- binocular. Two images gathered on a known baseline are brought into coincidence by a system of mirrors and prisms. The adjustment is used to determine distance. Used in some cameras (called range-finder cameras) and on a larger scale in early battleship range-finders
- interferometry. Interference fringes between transmitted and reflected lightwaves produced by a coherent source such as a laser are counted and the distance is calculated. Capable of extremely high precision.
- scintillometers measure atmospheric optical disturbances.
- fiber optic sensors.
- short path optical interception - detection device consists of a light-emitting diode illuminating a phototransistor, with the end position of a mechanical device detected by a moving flag intercepting the optical path, useful for determining an initial position for mechanisms driven by stepper motors.

Ionising radiation

- radiation sensors: Geiger counter, dosimeter, Scintillation counter, Neutron detection
- subatomic particle sensors: Particle detector, scintillator, Wire chamber, cloud chamber, bubble chamber. See Category:Particle detectors

Acoustic

- acoustic : uses ultrasound time-of-flight echo return. Used in mid 20th century polaroid cameras and applied also to robotics. Even older systems like Fathometers (and fish finders) and other 'Tactical Active' Sonar (Sound Navigation And Ranging) systems in naval applications which mostly use audible sound frequencies.
- sound sensors : microphones, hydrophones, seismometers.

Other types

- motion sensors: radar gun, speedometer, tachometer, odometer, occupancy sensor, turn coordinator
- orientation sensors: gyroscope, artificial horizon, ring laser gyroscope
- distance sensor (noncontacting) Several technologies can be applied to sense distance:

magnetostriction

Biological sensors

All living organisms contain biological sensors with functions similar to those of the mechanical devices described. Most of these are specialized cells that are sensitive to:

- Light, motion, temperature, magnetic fields, gravity, humidity, vibration, pressure, electrical fields, sound, and other physical aspects of the external environment
- Physical aspects of the internal environment, such as stretch, motion of the organism, and position of appendages (proprioception)
- Environmental molecules, including toxins, nutrients, and pheromones
- Estimation of biomolecules interaction and some kinetics parameters
- Internal metabolic milieu, such as glucose level, oxygen level, or osmolality
- Internal signal molecules, such as hormones, neurotransmitters, and cytokines
- Differences between proteins of the organism itself and of the environment or alien creatures

Artificial sensors that mimic biological sensors by using a biological sensitive component, are called biosensors.

Source : http://www.juliantrubin.com/encyclopedia/electronics/sensor.html