Assignment 6

Sensors

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1. Define Sensors.

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. The most frequently used different types of sensors are classified based on the quantities such as Electric current or Potential or Magnetic or Radio sensors, Humidity sensor, Fluid velocity or Flow sensors, Pressure sensors, Thermal or Heat or Temperature sensors, Proximity sensors, Optical sensors, Position sensors, Chemical sensor, Environment sensor, Magnetic switch sensor , etc. Types of sensors:

Temperature Sensor

A device which gives temperature measurement as an electrical signal is called as Temperature sensor. This electrical signal will be in the form of electrical voltage and is proportional to the temperature measurement.

Pressure Sensors

Pressure sensors are used for measuring the pressure of gases and liquids. Pressure sensors are used for control and monitoring in thousands of everyday applications.

Piezoelectric Sensor

A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge.

Magnetic Sensor

Magnetic sensors are designed and used to detect the magnetic field strength due to the existence of magnets. There are different types of and shapes for magnetic sensors. Some of which are designed to work in contactless applications such as door close indicators.

2. Why is silicon best preferred in sensor composition?

Silicon is used for electronic devices because it is an element with very special properties. One of it’s most important properties is that it is a semiconductor. This means that it conducts electricity under some conditions and acts as an insulator under others. Silicon’s electrical properties can be modified through a process called doping. These characteristics make it an ideal material for making transistors that amplify electrical signals. Silicon’s properties are not the only reason why it is ideal for electronic devices. Silicon is also an abundant element on Earth. It is even the most common element in the Earth’s crust. The abundance of Si allows it to be extremely affordable and appealing. Silicon does not exhibit fatigue, and has high strength and low density, making it suitable for micromechanical devices. It is no wonder why silicon has become the basis of memory chips, computer processors, transistors, and all other electronics. Without silicon and the silicon wafers they are manufactured into, most of the electronic devices you use everyday wouldn’t be possible. Linear parametric variation of silicon element with temperature makes it suitable for temperature measurement purposes. Silicon has light-sensitive parameters, making it suitable for light intensity measurements .

3. How does semiconductor Strain gauge work?

A strain gauge is a type of electrical sensor, primarily used to measure force or strain. A strain gauge is used as a precautionary measure in many testing applications. Usually, when a strain gauge gives a certain reading an alert will be triggered to inform the user that the capacity has been reached, this means that the issue can be addressed before it becomes dangerous.

When external forces are applied to a stationary object there are two forces present; stress and strain. Stress is the resisting force of the object (like a push back) strain is the displacement and deformation of the object and this is the force which can be measured by a strain gauge. Because they are small and highly sensitive strain gauges can measure the contraction or expansion of an object even if it is just a small amount when they are correctly bonded to an object or device. The resistance of a strain gauge changes when force is applied and this change will give a different electrical output. Strain gauges use this method to measure pressure, force, weight and tension.

Strain gauge technology has a huge amount of uses –

- Stress on railway lines
- Aircraft component testing
- Rotational strain on turbines, wheels, fans, propellers and motors
- Testing structural components for bridges and buildings

4. What is meant by Multi-sensor Data fusion?

Multi-sensor data fusion is the process of combining observations from a number of different sensors to provide a robust and complete description of an environment or process of interest. Data fusion finds wide application in many areas of robotics such as object recognition, environment mapping, and localization. Data fusion systems are often complex combinations of sensor devices, processing, and fusion algorithms. Most current data fusion methods employ probabilistic descriptions of observations and processes and use Bayes' rule to combine this information. Multiple sensors can be arranged and configured in a certain manner to obtain the desired results in terms of sensor nodes or decision connectivity. The applications of data fusion are pervasive in robotics and underly the core problem of sensing, estimation, and perception. the main probabilistic modelling and fusion techniques including grid-based models, Kalman filtering, and sequential Monte Carlo techniques.

5. Define Kalman Filter with the help of an example.

Kalman filtering is an algorithm that provides estimates of some unknown variables given the measurements observed over time. Kalman filters have been demonstrating its usefulness in various applications. Kalman filters have relatively simple form and require small computational power. The Kalman Filter is one of the most important and common estimation algorithms. The Kalman Filter provides a prediction of the future system state based on past estimations.

Example: Consider the problem of determining the precise location of a truck. The truck can be equipped with a GPS unit that provides an estimate of the position within a few meters. The GPS estimate is likely to be noisy; readings 'jump around' rapidly, though remaining within a few meters of the real position. In addition, since the truck is expected to follow the laws of physics, its position can also be estimated by integrating its velocity over time, determined by keeping track of wheel revolutions and the angle of the steering wheel. This is a technique known as dead reckoning. Typically, the dead reckoning will provide a very smooth estimate of the truck's position, but it will drift over time as small errors accumulate.

For this example, the Kalman filter can be thought of as operating in two distinct phases: predict and update. In the prediction phase, the truck's old position will be modified according to the physical laws of motion (the dynamic or "state transition" model). Not only will a new position estimate be calculated, but also a new covariance will be calculated as well.