UNIT-V

Smart Sensors:

- A smart sensor is a device that takes input from the physical environment and uses built-in compute resources to perform predefined functions upon detection of specific input and then process data before passing it on.
- Smart sensors enable more accurate and automated collection of environmental data with less erroneous noise amongst the accurately recorded information. These devices are used for monitoring and control mechanisms in a wide variety of environments including smart grids
- A smart sensor might also include several other components besides the primary sensor. These components can include transducers, amplifiers, excitation control, analog filters and compensation. A smart sensor also incorporates software-defined elements that provide functions such as data conversion, digital processing and communication to external devices.

How does smart sensor work?

- A smart sensor ties a raw base sensor to integrated computing resources that enable the sensor's input to be processed.
- The base sensor is the component that provides the sensing capability. It might be designed to sense heat, light or pressure. Often, the base sensor will produce an analog signal that must be processed before it can be used. This is where an intelligent sensor's integrated technology comes into play. The onboard microprocessor filters out signal noise and converts the sensor's signal into a usable, digital format.
- Smart sensors also contain integrated communications capabilities that enable them to be connected to a private network or to the internet. This enables communication to external devices.

How are smart sensors different from base(normal) sensors?

- Smart sensors include an embedded Digital Motion Processor (DMP), whereas base sensors don't. A DMP is, essentially, just a microprocessor that is integrated into the sensor. It enables the sensor to perform onboard processing of the sensor data. This might mean normalizing the data, filtering noise or performing other types of signal conditioning. In any case, a smart sensor performs data conversion digital processing prior to any communication to external devices. A base sensor is simply a sensor that isn't equipped with a DMP or other compute resources that would enable it to process data.
- Smart sensor produces output that is ready to use, a base sensor's output is raw and must typically be converted into a usable format.

Advantages

- These are small in size
- These sensors are very easy to use, design & maintain
- The performance level is higher
- Speed of communication & reliability is higher due to the direct conversion with the processor.
- These sensors can perform self-calibration & self-assessments.
- These sensors can notice issues like switch failures, open coils & sensor contamination.
- These sensors optimize manufacturing processes easily that need changes.
- They can store many systems' data.

Disadvantages

- Smart sensors' reliability is one of the major drawbacks because if they are stolen or get damaged then they can affect a lot of systems badly.
- It needs both sensors & actuators.
- Sensor calibration has to be managed by an external processor.
- High complexity in wired smart sensors, so the cost is also very high

Applications

- These sensors play a key role in monitoring different industrial processes like data collecting, measurement taking & transmitting the data to centralized cloud computing platforms wherever data is collected & analysed for different patterns. So, this collected data can be simply monitored at any time by decision-makers.
- Smart sensors are used mainly for monitoring & control mechanisms in different environments like water level & food monitoring systems, smart grids, traffic monitoring & control, environmental monitoring, conserving energy in artificial lighting, monitoring of the remote system, and fault diagnostics of equipment, transport & logistics, agriculture, telecommunications, industrial applications, animal tracking, etc.

The general structure of smart sensor and its components,

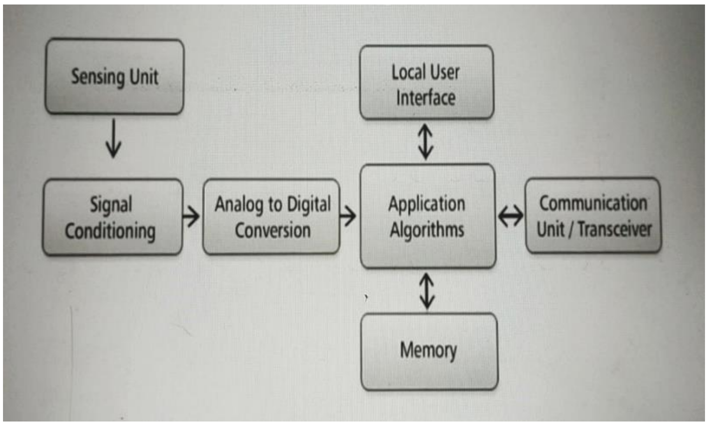

Fig. Smart Sensor

Sensing Unit
This unit detects the changes in physical parameters & generates electrical signals equivalent to it.

Signal Conditioning Unit
The signal conditioning unit controls the signal to meet the necessities of next-level operations without losing data.

Analog to Digital Converter
ADC converts the signal from analog to digital format & sends it to the microprocessor.

Local User Interface
The local user interface or LUI is a panel-mounted device used to allow building operators to monitor & control system equipment.

Application Algorithm
The signals from smart sensors reach here & process the received data based on the application programs previously loaded here & generate output signals.

Memory
It is used to store media for saving received & processed data.

Communication Unit
The output signals from the application algorithm or microprocessor are transmitted to the main station through the communication unit. This unit also gets command requirements from the key station to execute specific tasks.

Characteristics of smart sensors

Self-calibration: Self-calibration means adjusting some parameters of the sensor during fabrication, this can be either gain or offset or both. Self-calibration is to adjust the deviation of the output of the sensor from the desired value when the input is at minimum or it can be an initial adjustment of gain.

Self- testing: After the power is turned on, the sensor can be self-tested to check whether all parts of the sensor are normal, and can diagnose faulty components.

Self-communicating: Smart sensors will have mechanisms for synchronization communication between sensors and microcontrollers and support different data rates. Industrial Smart sensors come with a plug and play mechanism, like a CAN bus mechanism where they can be connected to the network and removed as easily as possible also a mechanism to identify their own identity in the network.

Application of Smart Sensors

- **Automatic robot control**

  - An integrated system based on a robotic manipulator is made where the robot can perform operation in real-time under dynamic conditions. Online planning is made to enable a robotic end effector to perform pick-and-place tasks within a given workspace. Such online planning consists of moving the robot to a start (pick) position, pick a given object, transport it to a given goal (place) position, and release it.
  - The proposed system consists of three independent modules: **machine vision, path planning and robot control** linked in parallel to form an efficient integrated system with wide modularity.
  - All modules work in real-time, and communications are maintained across modules.
  - The machine vision module performs obstacle detection, where dynamically moving obstacles are tracked in the robot workspace.
  - The decision-making process is derived from the path planning module, where the search for optimal, feasible paths for pick-and-place operations is performed based on input obtained from the machine vision to update the current geometric representation of the environment. These two modules communicate by TCP/IP sockets, where the machine vision software acts as a server, and the path planning module acts as a client.

- **Automatic engine control**

- Sensors play an important role in automotive. They enable greater degrees of vehicle automation and futuristic designs. For example, at manufacturing units, sensorized robotic arms are used for painting car bodies and measuring the thickness of the coatings being applied. Manufacturers can simply monitor the thickness of the paint being sprayed on instruments, airbag claddings, and various internal parts of the vehicles using sensors.
- Sensors monitor vehicle engines, fuel consumption, and emissions, along with aiding and protecting drivers and passengers. These allow car manufacturers to launch cars that are safer, more fuel-efficient, and comfortable to drive.