SMART SENSORS

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ABSTRACT:

Smart sensors represent the next evolutionary tools for studying the environment. The smart environment relies first and foremost on sensory data from the real world. Sensory data comes from smart sensors of different modalities in distributed locations. Smart sensor systems are capable of prediction, interpretation, communication and intelligent interaction with the environment & hence will leverage new fault management of devices and control for distributed resources. Tremendous advances in digital signal processing and laser capabilities in recent years have enabled many new sensor developments, one of these being smart sensors.

Fundamental research has already been carried out to develop smart sensors to monitor and control robotics, mobile vehicles, cooperative autonomous systems, mechatronics and bio-engineering systems. Emerging sensors and instrumentation technology can be exploited for enhanced research and operational capabilities. Such smart information technology manifests the potential for varied applications. It is envisioned that concepts of smart sensors and information technology can be transferred and applied to numerous systems. The implementation of large networks of interconnected smart sensors can monitor and control our world. Better understanding of smart sensors perform satisfactorily in real-world conditions and can help improve efficiency and reliability. A sensor network consisting of a large number of smart sensors, enabling the collection, processing analysis and dissemination of valuable information gathered in a variety of environments is being implemented quickly.
INTRODUCTION

Smart sensors are an extension of traditional sensors to those with advanced learning and adaptation capabilities. The system must also be re-configurable and perform the necessary data interpretation, fusion of data from multiple sensors and the validation of local and remotely collected data. These sensors therefore contain embedded processing functionality that provides the computational resources to perform complex sensing and actuating tasks along with high level applications.

The functions of a smart sensor system can be described in terms of compensation, information processing, communications and integration. The combination of these respective elements allow for the development of these sensors that can operate in a multi-modal fashion as well conducting active autonomous sensing.

**Compensation** is the ability of the system to detect and respond to changes in the network environment through self-diagnostic routines, self-calibration and adaptation. A smart sensor must be able to evaluate the validity of collected data, compare it with that obtained by other sensors and confirm the accuracy.

**Information processing** encompasses the data related processing that aims to enhance and interpret the collected data and maximize the efficiency of the system, through signal conditioning, data reduction, event detection and decision making.

**Communications** component of sensor systems incorporates the standardized network protocol which serves to links the distributed sensors in a coherent manner, enabling efficient communications and fault tolerance.

**Integration** in smart sensors involves the coupling of sensing and computation at the chip level. This can be implemented using micro electro-mechanical systems (MEMS), nano-technology and bio-technology.

**Validation** of sensors is required to avoid the potential disastrous effects of the propagation of erroneous data. The incorporation of data validation into smart sensors increases the overall reliability of the system.

**Data fusion** techniques are required in order combine information from multiple sensors and sensor types and to ensure that only the most relevant information is transmitted between sensors.
SMART SENSOR NETWORKS:

Wireless sensor networks are potentially one of the most important technologies of this century. A sensor network is an array of sensors of diverse type interconnected by a communications network. Sensor data is shared between the sensors and used as input to a distributed estimation system which aims to extract as much relevant information from the available sensor data. The fundamental objectives for sensor networks are reliability, accuracy, flexibility, cost effectiveness and ease of deployment.

A sensor network is made up of individual multifunctional sensor nodes. The sensor node itself may be composed of various elements such as various multi-mode sensing hardware (acoustic, seismic, infrared, magnetic, chemical, imagers, microradars), embedded processor, memory, power-supply, communications device (wireless and/or wired) and location determination capabilities.

A sensor network can be described by services, data and physical layer respectively.

SIGNIFICANCE OF SENSOR NETWORK:

- **Sensing accuracy:** The utilization of a larger number and variety of sensor nodes provides potential for greater accuracy in the information gathered as compared to that obtained from a single sensor.

- **Area coverage:** A distributed wireless network will enable the sensor network to span a greater geographical area without adverse impact on the overall network cost.

- **Fault tolerance:** Device redundancy and consequently information redundancy can be utilized to ensure a level of fault tolerance in individual sensors.

- **Connectivity:** Multiple sensor networks may be connected through sink nodes, along with existing wired networks (eg. Internet).

- **Minimal human interaction:** The potential for self-organizing and self-maintaining networks along with highly adaptive network topology significantly reduce the need for further human interaction with a network other than the receipt of information.

- **Operability in harsh environments:** Robust sensor design, integrated with high levels of fault tolerance and network reliability enable the deployment of sensor networks in dangerous and hostile environments.
CHALLENGES:

- **Changing network topology:** Advanced communication protocols are required to support high level services and real-time operation, adapting rapidly to extreme changes in network conditions.

- **Resource optimization:** Optimised sensor scheduling for distributed networks, through accurate determination of the required density of sensor nodes in order to minimize cost, power and network traffic loads, while ensuring network reliability and adequate sensor resolution for data accuracy.

- **Limitations:** Power, memory, processing power, life-time.

- **Failure prone:** Individual sensors are unreliable, particularly in harsh and unpredictable environments. Addressing sensor reliability can reduce the level of redundancy required for a network to operate with the same level of reliability.

- **Network congestion resulting from dense network deployment:** The quantity of data gathered may exceed the requirements of the network and so evaluation of the data and transmission of only relevant and adequate information needs to be performed.

  Security is a critical factor in sensor networks, given some of the proposed applications. An effective compromise must be obtained, between the low bandwidth requirements of sensor network applications and security demands.

APPLICATIONS OF SMART SENSORS:

- **SMART SENSOR FOR TIRE PRESSURE MONITORING:**

  Recent reports of accidents involving sport utility vehicles have led to tire recalls and finger-pointing at vehicle design, tire quality, tire pressure, or driver error as the underlying cause of the problem. The information must be wirelessly transmitted to the driver, typically via RF, and displayed in the cabin of the vehicle. The remote sensing module consists of a pressure sensor, a signal processor, a temperature sensor that compensates pressure variations due to temperature changes, and an RF transmitter. The system is powered by a battery with embedded intelligence that prolongs its operating life. Because battery replacement is out of the question, and replacing the entire module is not a cost-effective option for the average car owner, most of the existing specifications require up to 10 years of battery life.
TPMS (Tire Pressure Monitoring Sensor):
The receiver can either be dedicated to TPM use or shared with other functions in the car. For instance, the receiver controller could be the existing dashboard controller or the body controller. Or the receiver itself could be shared with the remote keyless entry (RKE) system since both systems are using the same frequency range. This “functional sharing” feature helps with the system cost, reduces design cycle time, and makes the TPMS easier to integrate into the automobile.

TPMS SENSOR MODULE

THE OTHER APPLICATIONS INCLUDE:

- **Bushfire response** using a low cost, typically dormant, distributed sensor network early warning and localisation of bush fires can be achieved, hence saving life and property, whilst reducing the cost of monitoring.
- **Intelligent transportation** low cost sensors build into roads and road signs can assist to manage traffic flow and inform emergency services of traffic problems.
- **Real-time health monitoring** a nano-technology based bio-sensor network can assist in monitoring an ageing population, and inform health care professionals in a timely manner of potential health issues.
- **Unmanned aerial vehicle surveillance** swarms of low cost unmanned autonomous and co-operating aerial vehicles could be deployed to conduct surveillance and monitoring in remote or hostile environments.
• **Water catchment and eco-system monitoring and management** sensor networks that keep track of water quality, salinity, turbidity and biological contamination, soil condition, plant stress and so on could be coordinated to assist environmentally sustainable management of entire water catchment areas

• **Robotic landmine detection** A sensor network for the detection and removal or deactivation of landmines. A reliable sensor network will enable the safe removal of landmines in former war zones, reducing the risk to those involved in the removal process. The cost effectiveness of the network will aid in its application throughout third world nations where the after effects of war continue to take a toll on people living in areas still containing live explosives. The utilization of smart sensor technology to detect explosives, will overcome difficulties in detection of un-encased landmines.

**CONCLUSION:**

Thus we conclude that the smart sensors are cost effective, highly accurate and reliable small in size and have a varied future scope beneficial to mankind. The sensor revolution are entirely practical applications that are just coming on the market.
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