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Civil Applications of Wireless Sensor Networks

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Abstract: ***Structural Health Monitoring (SHM) of buildings using wireless sensor networks is one of the most reassuring emerging technologies for mitigation of seismic hazard. This technology has the potential to change fundamentally the traditional systems of monitoring. This paper provides a basic introduction of wireless sensor network technology for the SHM***

Keywords: smart wireless sensor, wireless sensor network, structural health monitoring, large scale.

1. Introduction

Wireless Sensor Networks are the networks which consist of sensors which are distributed in an expedient manner. Wireless Sensor Networks consists of protocols and algorithms with self-organizing capabilities.These sensors work with each other to sense some physical phenomenon and then the information gathered is processed to get relevant results.
The WSN is built of nodes. These may vary from a few to several hundreds or thousands. Each node is connected to one or many sensors. Each sensor network node has several parts: a radio transceiver with an internal antenna or connection to an exterior antenna, an electronic circuit for interfacing with the sensors, a microcontrollerand an energy source, usually a battery.
A sensor node might vary in size from that of a grain of dust to shoe box. The cost of sensor nodes is also variable depending on the complexity of the individual sensor nodes. Cost and size constraints on sensor nodes result in corresponding constraints on resources such as memory, computational speed, energy, and communication bandwidth. The topology of the WSN can be a simple star network or an advanced multi-hop wireless mesh network. The propagation technique used are routing or flooding

2. Comparison with Ad hoc Networks

- Ad hoc networks use point-to-point communicationwhile Wireless Sensor Networks mainly use broadcast communication.
- wireless Sensor Networks are limited by sensors limited power, energy and computational capability while Ad hoc networks do not have these limitations.
- Sensor nodes may not have global ID because of the large amount of overhead and large number of sensors

3. Application of Wireless Sensor Networks

Wireless Sensor Networks Find their applications in wide range of fields such as:-

3.1 Area Monitoring

Area monitoring is a common application of WSNs. The Wireless Sensor Network is deployed over a region where some phenomenon is to be monitored. Examples of Area Monitoring are as follows:

- A military example is the use of sensors detect enemy intrusion.
- A civilian example is the geo-fencing of gas or oil pipelines.

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3.2 Health Care Monitoring

The medical applications can be categorized as: wearable and implanted. Wearable devices are those which are used on the body surface of a human being or just at close proximity of the user. The implantable medical instruments are those that are inserted inside the human body. There are many other applications of WSN in medical field e.g. body position measurement and location of the person, overall monitoring of unwell patients in hospitals and at homes. Body-area networks can gather information about an individual's health, fitness, and energy expenditure.

3.3 Environmental/Earth Sensing

There are many applications in monitoring environmental parameters, examples of which are given below.

3.3.1 Air pollution monitoring

Wireless sensor networks have been deployed in several cities to monitor the concentration of dangerous gases for citizens. Wireless Sensor Networks provide more mobility for testing readings in different areas.

3.3.2 Forest fire detection

A network of Sensor Nodes can be installed in a forest to detect when a fire starts. The nodes are equipped with sensors to measure humidity, temperature and gases which are produced by fire in the trees or vegetation.

3.3.3 Landslide detection

A landslide detection system makes use of a wireless sensor network to detect the slight movements of soil and changes in various other parameters that may occur during or prior to a landslide. With the help of gathered data it may be possible to know the occurrence of landslides long before it actually happens.

3.3.4 Water quality monitoring

Water quality monitoring involves analysing water properties in rivers, dams, oceans & lakes, as well as underground water reserves. The use of many wireless sensors enables the creation of a more accurate map of the water status, and allows the enduring deployment of monitoring stations in locations which are difficult to access, without the need of manual data retrieval.

3.3.5 Natural disaster prevention

Wireless sensor networks can effectively act to prevent the consequences of natural calamities, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time.

3.4 Industrial Monitoring

Wireless Sensor Networks are also used in Industrial Monitoring

3.4.1 Machine health monitoring

Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionality. Wireless Sensors can be placed in locations difficult or impossible to reach with a wired system, such as rotating machinery and untethered vehicles.

3.4.2 Data logging

Wireless sensor networks are also used for the collection of data for monitoring of environmental statistics. This can be as simple as the monitoring of the temperature in a fridge to the level of water in overflow tanks in nuclear power plants. The advantage of WSNs over conventional loggers is the live data feed that is possible.

3.4.3 Water/Waste water monitoring

Monitoring the quality and level of water includes many activities such as checking the quality of underground or surface water and ensuring a country's water infrastructure for the benefit of both human and animal. It may be used to protect the wastage of water.

3.4.4 Structural Health Monitoring

Wireless Sensor Networks can be used to monitor the condition of civil infrastructure and related geo-physical processes close to real time, and over long periods through data logging, using appropriately interfaced sensors.

4. What is Structural Health Monitoring?

The buildings and other structures such as bridges, tanks, etc are often exposed to severe loadings during their lifetime, especially at extreme events like earthquake, which causes serious concerns on the integrity of the structures that is closely related to the public safety. The disasters on the civil structures like collapses of buildings or bridges, often accompany a large number of casualties as well as social and economic problems, thus most of the industrialized countries are on the verge of increasing their budget for structural health monitoring (SHM) of their major civil infrastructures The SHM system often offers an opportunity to reduce the cost for the repair, maintenance and retrofit throughout the life-cycle of the structure.

5. Wired Structural Health Monitoring

In the Wired SHM system, the expensive cost for purchase and installation of the SHM system components such as data loggers, sensors, connecting cables, and computers, is a huge barrier. To assure that measurement data are reliably collected, SHM systems generally use coaxial wires for communication between sensors and the repository. The installation of coaxial wires in structures is generally very expensive and labour intensive. The maintenance cost of the SHM system increases as the system gets older. This limitation on economical realization of SHM system may prevent installation of large number of sensors enough to assess the accurate status of a large civil structure, if the big budget for the SHM system is not secured.

6. Wireless Structural Health Monitoring

Smart wireless sensor has been considered as an alternative tool for economical and accurate realization of structural health monitoring system. Smart wireless sensor is an emerging sensor with the following essential features: on-board micro-processor, wireless communication, battery powered, sensing capability, and low cost. When many sensors are implemented on a SHM system for a civil structure, wireless communication between sensors and data repository seems to be attractive in the aspects of the cost. Dense arrays of low-cost smart wireless sensors have the potential to improve the quality of the SHM dramatically using their onboard computational and wireless communication capabilities. These wireless sensors provides information which SHM algorithms can utilize to detect, locate, and assess structural damage caused by severe loading events and by progressive environmental deterioration as well as economical realization of SHM system. Information from densely instrumented structures is expected to result in the deeper insight into the physical state of the structural system.

7. Why go Wireless?

Automatically acquiring and processing data from the several hundred sensors needs monitoring, say, a moderately sized office building requires us to deploy a network. Naturally, the high cost of cabling required to set up a wired network of this size is a serious obstruction in developing large scale SHM systems, but tiny wireless sensors could be easily deployed. Today's battery-powered, coin-sized devices can contain a processor, significant flash memory, and a low-power radio, together with micro-electromechanical systems sensors capable of measuring vibration. Moreover, these wireless sensor nodes are relatively easy to mount within a few meters of each other. Dense placement greatly increases the spatial resolution of data collection and improves the quality of damage assessment .The real challenge, though, is how to develop software subsystems that can support a large scale network of wireless sensor nodes. The batteries on today's wireless sensor platforms barely last a few days, and nodes require a lot of energy in sensing and wireless communication. To conserve energy, sensor-node platforms can operate in various low-power modes, with sensor-node software intelligently duty-cycling the hardware components. In addition, this software can process data locally to reduce the amount of data transmitted wirelessly, a procedure called in network processing. Although these techniques are generally useful for a variety of networked sensing applications, SHM places additional stringent requirements on wireless sensor node software. SHM sensors generate data at extremely high rates — a single sensor, for example, can generate several hundred samples per second. Data from sensors or a suitably processed representation thereof must be reliably delivered across the network, but reliable communication in very noisy wireless environments is a significant challenge.

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Pragati Sachanis currently pursuing her engineering from Electronics and Communication branch from Poornima Institute of Engineering and Technology, Jaipur and is in her final year(8th semester) right now.