Applications of wireless sensor networks — A survey

Conference Paper · November 2017

DOI: 10.1109/ICIEEIMT.2017.8116858

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Applications of Wireless Sensor Networks – A Survey

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***Abstract*-Wireless Sensor Networks (WSNs) are spatially scattered independent sensors to track physical objects or monitor environmental data and collectively transmit the data to master station. WSN is deployed in numerous fields such as animal tracking, precision agriculture, environmental monitoring, security and surveillance, smart buildings, health care and so on. This paper presents various applications of WSN with the intention of disseminating various applications of WSN for the better understanding of the research community to apply WSN in further innovative fields.**

I. INTRODUCTION

WSNs are built of nodes which consist of a radio transceiver, microcontroller and sensors. Sensors having different applications can be used so that it can perform well in any area. Mainly sensors are classified according to the readiness for field deployment that focuses in the field deployment in terms of economy and engineering efficiency, scalability and cost. The main categories of sensors are given as physical, chemical and biological sensors. The Wireless Sensor Networks consist of data acquisition network and data distribution network. The network will be managed and controlled by a central station. The data acquisition network in the wireless sensor network is used to acquire data from different fields. The acquired data is transmitted to the master station by means of different wireless distribution techniques. The wireless distribution techniques include transmission using cellular phones, Computers, WLAN, WI – Fi etc. Once the acquired data reaches the master station, the data is analyzed and further processing is done. The main characteristics of WSN includes: energy harvesting, ability to cope with node failure, mobility of nodes, heterogeneity of nodes, scalability to large scale deployment, ability to withstand harsh environmental conditions and ease of use. The mentioned features ensure a wide range of application of sensor networks. The main application areas of a wireless sensor network can be classified as shown in Fig 1 and its objectives are given in table 1.

Fig 1. Application areas of Wireless Sensor Network

TABLE I
APPLICATIONS AND ITS OBJECTIVES

Applications	Objectives
Precision Agriculture	Senses the parameters like temperature and pressure and also ensures an accurate environment for the crop cultivation.
Environmental Monitoring	Senses all the environmental parameters and to prevent calamities like gas leakage, flood, forest fire etc.
Vehicle Tracking	Helps in preventing traffic congestion and parking system and also the location of the vehicle.
Health care Monitoring	Helps in the real time monitoring of the physiological signals and prevents the risk that may occur to its life.
Smart Buildings	Consumes low energy and provides home and building security to an extent
Security and Surveillance	Helps in the early detection of the enemies and vehicle tracking.
Animal Tracking	Monitors the animals by optimizing rearing conditions and controlling animal's stress level by monitoring the vibration and movement

II. WSN APPLICATIONS

A) Precision Agriculture

Precision agriculture aims at building cultural operations more resourceful, while reducing environmental impact. The information collected from sensors is used to appraise most favorable sowing density, estimate fertilizers and other inputs needs, and to more precisely predict crop yields. WSN plays an inevitable role in the field of agriculture. The architecture consists of the field provided with a number of wireless sensor nodes which are used for the collection and monitoring of data

IEEE ISBN No.978-1-5090-4527-3

like temperature, humidity, carbon dioxide gas levels, soil moisture etc. The sensed and collected data is sent to the human expertise through the cloud computing technology or by Internet. The researchers present in the central station can analyze and take further actions to improve the crop yield with low cost.Many researches are ongoing by including the sensors in agriculture. In [1], a real time monitoring of data using Zigbee to monitor the climate and other environmental properties are done using the wireless sensors. The main objective of the paper is to report all the design, construction and testing of all the environmental properties that is required for the precision agriculture using wireless sensor networks. Different topologies like delay, throughput and load is calculated and simulated. The main advantages are improving quality of precision agriculture, low cost and ease in deployment and system maintenance. A new technique named Integrated WSN Solution for Precision agriculture is proposed in [2]. The system integrates crop data acquisition, data transfer to the end station and video surveillance. The system provides agriculture data monitoring, long distance transmission and camera sensors to evaluate the overall performance. The product characterization and quality of the specialty crop using sensors is discussed in [3] and [4]. A ground based real time monitoring system for the detection of plant disease under the field condition is discussed in [5]. It uses spectral reflectance measurements and fluorescence induction approaches to detect the plant diseases. Imaging fluorescence disease detection is done by considering the patches present in the plants. The other parameters considered are waveband selection and quadratic discriminant analysis.

Wireless sensor networks in agricultural water management are discussed in [6]. The input given to the sensor is soil moisture, daily rainfall, sunlight hours, humidity and wind speed. The threshold value is predefined and once the value exceeds the limit, the system will give an alarm as a safety measure. [7] Provide three different complementary approaches that make use of the psychometric properties of the air within the dying chamber and the temperature oscillations. Two experiments to find the dynamic characterization of the air inside the dryer and the energy access in the solar radiation. A precision irrigation system is provided by integrating a center pivot irrigation system with wireless underground sensor network is explained in [8]. The result of the proposed system shows that the wireless channel between soil and air is affected by the spatial-temporal aspects like location, burial depth, soil texture, soil moisture and canopy height. A real time monitoring system to monitor the agriculture environment is detailed in [9]. The system is based on the wireless sensor networks and also the paper details about the hardware used. The system is found to be having low power consumption, stable running and high precision which is an advantage. A system is proposed to analyze the use of programmable system on chip technology as a part of WSN to monitor the various parameters in greenhouse is discussed in [10]. The system helps in monitoring and controlling the greenhouse parameters in precision agriculture. For long term calibration and validation applications, the use of wireless sensor network in the automated soil moisture monitoring is discussed in [11]. The network is comprised of a number of automated measuring stations and it aids in monitoring the soil moisture in real time. Thus the use of wireless sensor networks in the field of agriculture helps in the collection of weather, crop and soil information, monitoring of the crops and land.

B) Environmental Monitoring

The use of wireless sensor networks in environment extends its application in coal mining, earth quakes, tsunami, flood detection, forest fire prediction, gas leakage, cyclones, rainfall range, water quality, and volcanic eruption and so on. As the network provides an early detection and prediction of all these environmental calamities, it helps in taking a safety measure to certain level. The data is sensed using the sensors and is transmitted to the master station via Internet. This helps in taking precautions and also aids in making people aware of the disaster that is about to come. The application of wireless sensor network in the environmental monitoring application is discussed here.

1. Air Pollution

The chemical reactions that involve air pollutants create the poisonous ozone gas which affect people's health and also it can damage the plant and animal life too. So for the earlier detection of these air pollutants wireless sensor networks are used. [12] focuses on the wireless sensor network components that can be selected in the monitoring of air pollution. This helps in the measurement of harmful air pollutants and basic meteorological particles. A wireless sensor network for monitoring air pollution in Mauritius is discussed in [13]. The system make use of the air quality index. By comparing the obtained data with the index value, the system detects the polluted air.

2 .Forest Fire

In most of the countries like Australia, the occurrence of forest fire is common because of the dry and hot climate. This will damage the wild lives. In order to prevent the forest fire to some extend wireless sensor networks are used. [14] and [15] describes the use of wireless sensor networks in the early detection of forest fires. [14] proposes a comparative study between the two forest fire detection methods like Canadian approach and Korean approach. The method used WSN to detect the fire using the sensor test bed. It considers the features like energy efficiency, early detection and accurate localization, forecast capability and they are adaptive to the harsh environmental conditions. Two different algorithms based on the information fusion techniques are proposed in in [15], a frame work to detect the forest fire using wireless sensor networks is proposed. The framework helps in the detection of the forest fire earlier. The energy consumption of

IEEE ISBN No.978-1-5090-4527-3

the sensor nodes is very less. The system is capable of performing in any kind of environmental conditions.

3. Gas Leakage

Gas leakage is another hazardous problem that may cause damage to human life as well as animal life. The application of wireless sensor networks in detecting the gas leakage is discussed in [16] and [17]. A remote online carbon di oxide monitoring system is developed in [16]. The system consists of central processing unit, air environment sensor arrays, GPS, receiver module, secure digital memory card storage module, LCD and GPRS. The data will be stored and displayed and it also has the ability provide an alarm if the situation goes beyond control. An ultra-wide band sensor network is used in the exploration of oil and gas in [17]. A seismic acquisition system is introduced for the exploration of oil and gas in oceans.

4. Coal Mines

Another important application of wireless sensor network is in the coal mining. The people working in the coal mines are facing many dangerous hazards like Cave-ins, gas explosion, vehicle or equipment collision or crushing, chemical leakage, electrocution and fires. So it is inevitable to monitor those fields continuously for the safety of the people working in the mines. [18] and [19] details the application of wireless sensor networks in the coal mines. [18] uses a chain type wireless underground mine sensor network. The sensors collect the information on the environment and the location. As the parameters like temperature and chemical rates are continuously monitored using the sensor, it prevents the chance of danger to an extent. In [19], the reaction time of detecting fire hazard in a Board-and- Pillar coal mine panel is presented. It uses wireless sensor networks (WSNs), and can be used to detect the exact fire position and dispersal course, and also offer the fire prevention system to stop the spread of fire to save the natural resources and mining human resources from fire

5. Water Quality

Another important application of WSN is to monitor the quality of water. Various water quality parameters such as pH, ammonia, dissolved oxygen, water level and so on can be monitored by using WSN and discussed in [20] and [21]. Three types of monitoring methods are used in monitoring water environment in [20]. CDMA based remote wireless water quality monitoring for fish culture is detailed in [21].

C) Vehicle Tracking

Smart transportation is another application of WSN. Networked cameras and other sensors that is used to monitor the traffic flow to reduce congestion, tracking of vehicles on city for traffic violation and to detect illegal activities around the critical infrastructure like airports, railway station etc. [22] – [24] details the application of WSN in smart transportation. In [22], it provides the possible benefits of using WSN based traffic monitoring system for the improvement of quality and safety of vehicle transportation. In [23], the paper describes a solution for the intelligent transportation system using wireless sensor networks. In [24], it describes the design and execution of an ecological wireless sensor network that characterizes air quality in Asuncion, Paraguay. Mobile sensor devices in public transport vehicles offer a useful means to build up a well-organized result for this classification.

D) Health care Monitoring

Nowadays, the use of WSN in medical field is inevitable. The system consists of sensors to sense various physiological parameters. The sensed parameters are then passed to the practitioner for further analysis and diagnosis. Several works have been done by using WSN. Here few applications of WSN in health care is detailed from [25] – [31]. In [25], a novel home monitoring system based on cognitive sensor network for elder care applications is developed. The system consists of an optimum number of cognitive wireless sensors to detect the usage of the electrical devices, bed usage pattern and water flow. Apart from the detection it incorporates a panic button for the patients in case of emergency. A multi sensor system to monitor the physical activities of the patient is detailed in [26]. The system helps in monitoring the fitness level and exercise capacity, helps to reduce the risk factors like obesity, blood pressure and diabetics and also improves the health of cardio vascular system and hence helps in expanding the life expectancy. [27] presents a novel design to develop a wireless sensor network structure to monitor multiple patients with chronic disease. [28] presents a remotely operated physiological monitoring system. The system is capable of working without patient's intervention. A survey on the health care sector using wireless sensor network is detailed in [29] which reviews different methods that coordinates wireless sensor network for health care applications. A WAP based telemedicine system is developed in [30] which uses WAP devices as mobile access point. [31] describes the design requirements for the ECG sensor and the system design which is developed for monitoring patients with chronic disease in real time. The patient will be wearing the ECG sensor and the sensor will continuously transmit the data to the hospital or to the physician without any fail which will results in the continuous monitoring of the patient.

E) Smart Buildings

An intelligent building is able to monitor and control its own functionalities, according to the building structure, indoor and outdoor environment. The functionalities and their characteristics are directly related to building scope. [32] – [36] details the use of WSN in smart building development. Nagendar et.al., in [32] designed and developed a smart monitoring and controlling system for household electrical appliances in real time. The system monitors the current and voltage consumed by the house hold appliances. The advantages of this system are low cost and flexible in operation. [33] proposes a novel design for the smart home using WSN and biometric technologies. The system employs authentication for home entrance and provides home security.

IEEE ISBN No.978-1-5090-4527-3

[34] details a case study of WSN in supporting the energy management utilizing web service and middleware technologies. The approach proposes the integration of WSN with wireless communication technologies to support the energy management in smart buildings. Wireless Sensor Network enabled smart home environments to create pervasive and ubiquitous applications is presented in [35]. The system enables a scalable service and context awareness to the end user. The system also develops an application and reports its realization in genuine WSN to offer remote home security. [36] develops an automatic wireless sensor network for civil engineering structures. This system is capable of measuring both temperature and humidity with in the concrete structure.

F) Military Applications

WSN plays a vital element of armed command, control, communications, computing, intelligence, surveillance, reconnaissance and targeting (C4ISRT) systems. The quick exploitation, self-organization and error acceptance distinctiveness of sensor networks create them a very hopeful sensing technique for military C4ISRT. Since sensor networks are based on the thick exploitation of not reusable and low-cost sensor nodes, devastation of some nodes by aggressive actions does not affect a military operation as much as the obliteration of a customary sensor, which makes sensor networks notion an enhanced approach for battlefields. [37] and [38] details the application of WSN in military surveillance applications. In paper [37], a novel tiered sensor networking architecture that employs the advanced wireless sensor network technology for military operation is discussed. The architecture results in agile surveillance systems that focus on an improvement in the operational flexibility and usability. Wireless sensor network to detect and track the vehicle of enemies is detailed in [38]. The system continuously monitors and detects the movement, location and position of the vehicle.

G) Animal Tracking

Animal tracking is another application of wireless sensor networks in which a sensor is attached to the animals' body so that the transportation and position of the animal can be identified. An example of using wireless sensor networks in animal tracking is Zebra Net which is used to track the zebras in the field. The sensors are attached in the animal's body so that the position, location and the kind of food they are consuming can be monitored. Zebra tracking is one of the main applications of WSN in animal rearing. The collar-mounted sensors are attached to the zebra's neck. This sensor will help in the tracking of zebra continuously. Many researches are happening in the animal tracking and transportation field using sensor Networks. [39] – [43] gives different animal tacking and monitoring methods using wireless sensor networks. In [39], the paper provides a design to locate the cattle in the grazing fields using WSN. The main features of this system are low cost, due to the potentially elevated number of nodes necessary for monitoring an whole flock of cattle, well-organized energy supervision in order to supply organization with a sensible act time and independence from added hardware which can increase costs and lessen mobility and sturdiness of mobile devices. A survey on animal tracking system using WSN is detailed in [40]. It provides the details on the sensor nodes that can sense gauge and collect information from the surroundings, some restricted choice development and they can broadcast the sensed data to the end user. In paper [41], it proposes and studies a WSN based system for generic target animal tracking like animal tracking in the nearby area of flora and fauna passages built to set up secure habits for animals to cross transportation infrastructures. In addition, it allows target recognition through the employment of video sensors associated to intentionally deployed nodes. In [42], the paper proposes a simple recovery method to locate the lost targets when tracking the wild life failure occurs. The application of wireless sensor networks in the real time habitat monitoring is detailed in [43]. Apart from the habitat monitoring, the system is also capable of predicting the system operation and the network failures.

Apart from the mentioned applications, wireless sensor networks are used in many other applications like security and surveillance, chemical monitoring, biological parameter monitoring etc.

I. CONCLUSION

Various deployments of Wireless Sensor Networks and its characteristics such as flexibility, fault tolerance, high sensing dependability, low-cost and quick employment have been studied. In future, this wide range of deployment areas will make sensor networks a vital part of our lives.

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