Overview of Applications of Wireless Sensor Networks

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Abstract— Wireless sensor networks (WSNs) have become a popular research topic recently due to their wide applications. Such wide applications also drive the development of WSNs because usually, the development of WSNs comes from challenges in real applications. Therefore, it is worthwhile to review some real applications to see how WSNs can be used and developed in the future to address more practical challenges.

Index Terms—Applications, medical area, wireless sensor networks.

I. INTRODUCTION

Due to a vast number of applications, wireless sensor networks (WSNs) have gained significant attention [1]-[35]. WSNs can perform many tasks, such as tracking, detection and estimation [31]. These tasks are basis of many applications. Because real challenges in the application of WSNs drive the development of WSNs, it is useful to review some applications of WSNs. The purpose of this review paper is to provide readers some details of real applications so that in the future readers can design WSNs to meet challenges in industry.

This paper is organized in the following way. Section II presented major application areas of WSNs. Applications of WSNs in environmental monitoring are presented in Section III, followed by applications in machine health monitoring and structure monitoring in Section IV. Section V provides applications in health care and Section VI presents applications in fire rescue, humanitarian search and rescue system. Applications in traffic and transportation management are presented in Section VII. Finally, Section VIII delivers concluding remarks.

II. MAJOR APPLICATION AREAS OF WSNS

In this review paper, we will discuss five main application areas of WSNs. The five application areas are: 1) environmental monitoring; 2) machine health monitoring and structure monitoring; 3) health care; 4) fire rescue, humanitarian search and rescue system; 5) traffic and transportation management. Now these five application areas are discussed in details.

III. ENVIRONMENTAL MONITORING

Environmental monitoring is an important research area and is a corner stone for many other researches. For example, a WSN is used to monitor behaviors of birds in Leach's Storm Petrel on Great Duck Island, Maine, United States in [2]. Sensors are installed to monitor the environment in burrows and to minimize the disturbance by human beings. Usually burrows are concentrated in clusters.

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After collecting information from the sensors in the cluster, a sensor node with long-distance communication ability sends data to a central base station computer. The base station computer will then forward information to a backend database system. Therefore, the whole system forms a multi-hop transmission link. Details of this experiment are provided in [3].

WSNs can also monitor large-scale environment phenomena, such as sunlight, humidity, temperature, and air pollution [1]. Usually, such monitoring tasks require dense sensor deployment, such as 10 sensors/m^2, to acquire enough samples. However, this kind of dense deployment is infeasible. A new Networked Info-mechanical System (NIMS) architecture was developed in [1], which solved this problem. In NIMS architecture, fixed sensor nodes are combined with mobile sensor nodes to reach a large area, which neither fixed sensor nodes nor mobile sensor nodes alone can cover that. Detailed can be found in [1].

By monitoring temperature, humanity, and illumination intensity, WSNs can also be used to monitor agriculture field [4]. Details of system design can be found in [4].

IV. MACHINE HEALTH MONITORING AND STRUCTURE MONITORING

Another important application area of wireless sensor networks is machine health monitor [5]. One such system includes a set of hardware and software platforms as well as a communication control component. Compared with wired sensors, a wireless sensor system reduces the cost of the whole system because no wiring is needed. Moreover, it is more convenient to deploy wireless sensors than wired sensors. Powered by battery, wireless sensors consistently observe machine health condition and transmit information back to a LABVIEW graphical interface through an energy efficient collision free protocol. Maintenance staff can be notified as soon as problems happen to the machine. More details can be found in [5]. Another related application of WSNs is structure monitoring, in which WSNs are employed to monitor damage in buildings, bridges, ships, and aircrafts [6]. Structure monitoring systems, after built, usually measure system structure response to excitation and, based on the response, determine the extent and location of damage [6]. A real WSN system, called Wisden, was built and deployed in an office building. The experiment results are promising and details can be found in [6].

V. HEALTH CARE

WSNs also find application in the health care area [7][8]. In some hospitals, doctors and nurses can localize patients and monitor the status of patients through WSNs.

As described in [7], a system called CodeBlue can monitor vital signs of patients and localize patients. The system can notify a doctor immediately if an emergency happens, thereby significantly shortening the response time.

Another similar example is presented in [9]. In this example, the system is proposed to monitor blood pressure, body temperature, heart rate, blood glucose, and so on. This system has a Hierarchy Architecture to facilitate communication within the hospital and communication between the hospitals to the health department of government.

Other application examples in the health care area can also be found in literature, such as, urban telehealth in [10], medical asset tracking in [11], and power reeducation in medical application in wireless sensor network in [12].

VI. FIRE RESCUE, HUMANITARIAN SEARCH AND RESCUE SYSTEM

WSNs can also be applied in fire rescue [13]. It is well-known that timely and accurate fire rescue activities are essential to save lives and properties. The nature of fire rescue activities determines that the fire rescue system must meet specific requirements, among which are accountability of firefighters, real time monitoring, intelligent scheduling and resource allocation, and web-enabled service and integration [13]. Current fire rescue systems, such as GEOMAC, Finder, and Geographic information system (GIS), are not efficient. To meet these requirements, a new system was developed in [13], called FIRENET. FIRENET is based on a WSN and sensors deployed can self-organize and change to an ad hoc network. In sum, FIRENET is a promising system to meet specific challenges in fire rescue system.

Another example involves the design of humanitarian search and rescue system [14]. In natural disasters, such as earthquake, tornadoes, and terrorism attacks, rescue teams have to reach the collapsed buildings to search for survivors. According to [14], trained rescue dogs can find human bodies but they cannot provide general information of surrounding environment of people to be rescued. Camera mounted probes can only provide pictures within 4-6 meters distance along a straight line while wireless mobile robot tracking system can provide information from longer distance [14]. The robot works within a wireless networks and the robot itself and is built based on an ATMEGA328P microcontroller board [14]. Details can be found in [14].

VII. TRAFFIC AND TRANSPORTATION MANAGEMENT

Traffic management is also an important application area of WSNs. In [15], a WSN system was developed to avoid collision in road intersections. In this system, every car is equipped with special radio module to communication with other cars in surrounding area. By collecting information from other cars, the node system installed in the car can predict possible trajectories and derive the best possible action to avoid car accidents. Another example in this category involves the tracking of fresh food [16]. According to [16], fresh food is susceptible to damage due to temperature variance, microbial infection, mechanical damage, and so on. A novel acceleration data collection system is developed to monitor the mechanical damage [16]. The system is based on dual layer network-topology: a Wide Area Network layer, and a Sensor Area Network. Details of this application can be found in [16]. Another example of traffic and transportation management is about managing parking lot, which can be found in [17].

VIII. CONCLUSION

In this paper, applications of WSNs were reviewed. Usually, the development of WSNs is driven by real applications in the world. Therefore, it is useful to know the applications of WSNs.

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