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A REVIEW ON WIRELESS SENSOR NETWORK IN AGRICULTURE

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Abstract:

Precision agriculture refers to applying various tools and technologies in agriculture for irrigation, fertilizer spraying, cattle monitoring etc. It is an information-based and technology-driven agricultural system, designed to improve the agricultural processes to ensure maximum agricultural production. Wireless sensor networks are used in agriculture for collecting and processing the environmental data. The developments in sensor networks is leading to advances in agriculture, physical building security, fire fighting, warfare and a number of industrial areas. This paper presents a review on application of wireless sensor networks in agriculture and the challenges.

Keywords: Wireless Sensor Network, Applications, Precision agriculture.

1. INTRODUCTION

Agriculture sector, at present, provides livelihood to 65 to 70 percent of the total population and plays a major role. Precision Agriculture is information-based and technology-driven agricultural system applying various technologies such as sensors, embedded system, Global positioning system etc., Wireless sensors have been used in precision agriculture to assist in spatial data collection, precision irrigation, variable-rate technology and supplying data to farmers [16]. Wireless sensor networks are applied in agriculture for a variety of applications such as irrigation, cultivation, fertilizer management, pesticide spraying, animal monitoring etc. Wireless sensor network is a collection of sensor nodes having high processing power used in monitoring environmental factors such as temperature or humidity change, motion and light intensity.Each sensor node comprises of five components such as sensor/actuator, controller, communication device, memory and power supply. The sensors gather the environment data and are processed intelligently by an embedded system. The information is transmitted to a decision centre by wireless communication network, which provides remote monitoring and management of the agricultural environment [22].

The paper is organised as follows: The section1 presents the introduction of wireless sensor networks. The section 2 presents the background and related work of applying sensors in agriculture. The section 3 presents the wireless sensor network architecture. The section 4 presents the challenges and section 5 presents the applications of wireless sensor networks. Finally the paper is concluded in section 6.

2. RELATED WORK

Michael J. Delwiche et al. (2013) [19] developed a valve actuation system for irrigation using sensors. They developed node firmware, actuator hardware, base station which is the gateway with control and Communication and web interface software to monitor node and mesh network status and view sensor data values. The system used a mesh-network topology, thus providing on-demand, bidirectional, multiple communication pathways between each node and the base station. The results showed that reducing water use by 10% would result in water savings of 37,004 m3 (30 ac-ft) which would save the grower $1500 per year for water valued at $41 per 1000 m3. It was estimated that an irrigator would work at 50%time for 13 weeks during the peak of the irrigation season to operate irrigation pumps and valves and do maintenance. This system used a mesh topology to provide multiple pathways between the nodes and the base station which leads to more energy consumption.

Salleh.A et al (2013) [20] designed a low cost green house monitoring system for measuring the temperature and humidity. The wireless sensor network consists of DC power supply 9V, Zigbee, PIC Microcontroller 16F877A, LCD screen and temperature and humidity sensor. MPLAB software is used to design the connection and all the interface process and C compiler was used for programming. The temperature and humidity sensors measured the data and send to the microcontroller to convert from analog form to digital form. The system continuously monitors the temperature and humidity values and transmitted using Zigbee transmitter and receiver.

Ballari.D et al (2012) [5] designed a model which abstracts mobility constraints within different types of contexts for the inference of mobile sensor behaviour. This behaviour is focused on achieving a suitable spatial coverage of the WSN when monitoring forest fire risk. The proposed model used Bayesian network approach and consists of three components: (1) a context typology describing different contexts in which a WSN monitors a dynamic phenomenon; (2) a context graph encoding probabilistic dependencies among variables of interest; and (3) contextual rules encoding expert knowledge and application requirements needed for the inference of sensor behaviour. It is shown that the implemented Bayesian network within the mobility constraint model can successfully infer different behaviour of sensors. They adopted different scenarios such as low fire risk level and higher fire risk level to address the inference of sleeping behavior and moving behavior.

NesaSudha et al (2011) [17] developed an energy conservation mechanism based on TDMA scheduling for automatic irrigation systems. A TDMA based MAC protocol was used to collect environmental data such as soil moisture and temperature of an irrigation system. The base station was collecting the data in a particular area using the sensor nodes and data aggregation was used to improve the energy efficiency. Data aggregation is the method of collecting the data from all sensor nodes by the cluster head and aggregates the data using the methods such as sum, minimum, maximum and average. This system improved the energy efficiency and network lifetime compared to the previous systems. The aggregation method showed better performance than the direct communication method in terms of average energy and the throughput of the network.

Huircan.J.I et al (2010) [10] designed a localization scheme in wireless sensor networks for cattle monitoring. The ratio metric vector iteration (RVI) algorithm was implemented to work with link quality indication (LQI) measurements. A WSN composed of a network coordinator implemented with a JN5139-Z01-M02 device, one JN5139-Z01-M00 sensor node and four JN5139-Z01-M02 devices which are used as routers. Modules JN5139-Z01-M00 contains an embedded ceramic antenna which encapsulates the device in a low weight small size plastic container. The scheme obtained a mean localization error in the order of 20 m, which is reasonable for a basic cattle monitoring system, while keeping hardware costs and communication overhead low.

Dimitrios D. Vergados et al (2009) [18] discussed various schemes for energy conservation in wireless sensor networks. They proposed a TDMA based scheduling scheme that reduced end-to-end delay and improved energy-saving. The data packets are delayed by only one sleep interval for the transmission from the sensors to the gateway. The idle listening time and sleep-related end-to-end delay is minimised using path-wakeup and the wakeup message aggregation strategies. The algorithm works in two phases such as set up phase and energy saving phase. The set up phase creates the transmission schedule and send to all sensor nodes using flooding technique. The energy saving phase calculates the sleep period and wake up period. The proposed scheme achieves higher power conservation only when the traffic generation rate is low and can be used for WSNs monitoring rare events which operate for a long period of time.

3. WIRELESS SENSOR NETWORK ARCHITECTURE

Wireless sensor network is a collection of small devices having high processing power which is used in monitoring environmental factors. It is a collection of various sensor nodes which are of two types. The source node is the one which sense the environment and collects the data and the sink node is the one which receives the data from the source node [14][23]. Figure 1 shows the diagrammatic representation of wireless sensor node. The sensor node comprises of controller, memory, sensors and actuators, communication device and power supply. The sensors are used to measure the environmental factors and the actuators are used to control the hardware. The microcontroller in the sensor node is programmed using various languages such as C, nesC, etc. The memory stores the data collected from the sensor node and from other nodes. The

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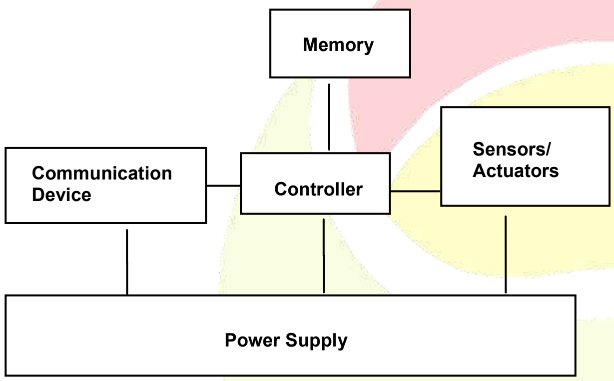
transceiver is a communication device used to send and receive the data collected from the sensors. The sensors commonly used in irrigation are soil moisture sensor, temperature sensor and humidity sensor.



A WSN consists of various sensor nodes to measure the data from the environment which is communicated to other nodes and to the base station [23]. The base station stores the sensor data and transmits the data to a remote system through Internet or some other communication medium such as Zigbee. The architecture of a WSN is shown in Fig 2.

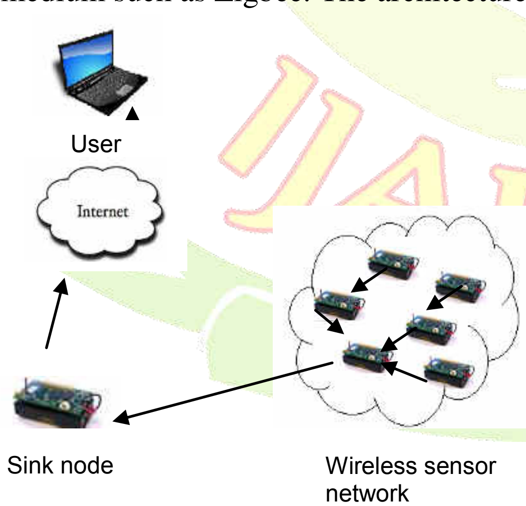


Fig 2.Wireless sensor Network Architecture

4. CHALLENGES

4.1 Energy Conservation

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The main challenge in wireless sensor networks is energy conservation [7] [18] since they are operated using batteries which affects the lifetime of the sensor node. The problems such as idle listening, overhearing and collision is to be minimized to increase the lifetime and to achieve energy efficiency. A TDMA based MAC protocol is used to prevent radio interference and to reduce energy consumptions [7]. A TDMA based scheduling was proposed to balance energy saving and end to end delay [18]. NesaSudha et al (2011) [17] developed an energy conservation mechanism based on TDMA scheduling. The computation requires more energy than communication and making the node to be in sleep state also reduces the power consumption [7].

4.2 Interconnection and Networking

The sensor nodes communicate through low power wireless communication. The technologies such as Zigbee, Bluetooth, wibree and wifi are compared based on range, power consumption, cost and data rate [1]. Zigbee is the common standard used for communication because of its low cost, low power consumption, and greater useful range in comparison with other wireless technologies. The data collected from the sensors are sent through ZigBee radio transmitter to the base station [15] [20]. IEEE 802.15.4 was used for communication between the Soil motes and the Gateway mote which is simpler to implement [13].

4.3 Quality of Service (QoS)

The QoS is one of the key issue and the parameters are latency, error rate, bandwidth, loss, secure authentication and throughput. The QoS requirements are different for different applications like agriculture, healthcare monitoring, natural disasters, etc. Providing QoS is a challenging issue due to various factors such as Limited energy resource of sensor nodes, unreliable wireless links and harsh operation environments [2].The various challenges for providing QoS are resource constraints, node deployment, topology changes, data redundancy, real-time traffic and scalability.

4.4 Sensor node housing

Sensor nodes should be secured from physical damage and interference. The anchor nodes are cased in a plastic container to prevent from damage which could be caused by animals [4].

4.5 Data acquisition and Transmission

The data aggregation method was used by Nesa sudha et al to reduce the energy consumption. In this method, the nodes themselves are formed into clusters and send the data to the cluster head which performs data aggregation [17]. The data acquisition, processing and transmission conserve energy. The sampling rate for data acquisition should be reduced to conserve the energy [1]. The data compression and aggregation reduce communication cost and increase reliability of data transfer. These techniques are necessary for WSN applications having large amount of data to send across the network [9].

5. APPLICATIONS

5.1 Automated Irrigation system

Nesa Sudha et al developed an automated irrigation systems based on TDMA scheduling. They have used temperature sensors and moisture sensors for measuring the environmental data and data aggregation method was used to reduce the energy conservation [17]. Jaume Casadesús et al. [8] developed an algorithm for automated scheduling of drip irrigation in tree crops based on particular requirements of each orchard and to the variability caused by weather conditions. Michael J. Delwiche et al developed a valve actuation system for irrigation using sensors. They developed node firmware, actuator hardware, base station which is the gateway with control and Communication and web interface software to monitor node and mesh network status and view sensor data values [19].

5.2 Cattle Monitoring

Huircan.J.I et al designed a localization scheme in wireless sensor networks for cattle monitoring [10]. Kae Hsiang Kwong et al used wireless sensor networks (WSNs) for monitoring the condition of individual animal, aggregating and reporting these data to the farm manager [11]. The connectivity between each collar leading to an unstable routing path and resulting in increased packet delay and an Implicit Routing Protocol (IRP) is designed to reduce the problem of mobility.

5.3 Green house Monitoring

Salleh.A et al designed a low cost green house monitoring system for measuring the temperature and humidity [20]. An integrated framework consisting of hardware and software components as well as tools that support efficiently the development of an autonomous WSAN-based system for precision irrigation in greenhouses was developed C. Goumopoulos et al [4].

5.4 Land Monitoring

Land monitoring is a critical task to ensure the quality of agricultural production in traditional precision agriculture. Shanahan Li et al proposed the INCremental sensOr deploy-MEnt solution – INCOME – to solve the sensor deployment problem in the field for practical land monitoring. The number of sensors used is reduced by repeating the deploy- sense-redeploy process and satisfied the measurement precision requirement and the size limitation requirement [21].

5.5 Seed Detection

Falate et al presented the use of the Infrared Sensor DFRobot RB-DFR-49 for detecting the maize seed and determined the distance between seeds by using a microcontroller. The Infrared Sensor composed of an infrared transmitter and a receiver, with an adjustable sensing distance that change from 30 mm to 800 mm. The sensor returns in its output/data pin 0 V when no object is detected and 5 V when an object is inside the detection range [6].

6. CONCLUSION

This paper reviews the wireless sensor network applications in agriculture. The sensors are used in monitoring the environmental factors such as temperature, moisture and humidity. The temperature sensors and moisture sensors are used in automated irrigation systems, Forest fire risk monitoring and green house monitoring. The sensors are applied in agriculture to reduce the manpower involved and to improve the productivity in low cost.

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