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Framework for Agriculture Automation using Wireless Sensor Networks

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Abstract: The main aim of this paper to explore the potential of Wireless Sensor Networks (WSNs) technology in agriculture, which can help to replace some of the traditional methods of farming and improves decision making. There are immense application of WSNs for collecting, storing and analyzing or sharing sensed data. They can be used for various applications like habitat monitoring, agriculture, nuclear reactor control, security and tactical surveillances. In this project, there are several external sensors like soil moisture, atmospheric pressure, leaf wetness, soil pH sensors attached. Depending on the value of soil moisture sensor, the system will trigger the water sprinklers at the time of water scarcity. When there is sufficient water, the sprinkler will be turned off. This will also conserve the water. Also, system will sent the value of soil pH to the base station which will inform the farmer about the soil pH via SMS using GSM modem. This will help the farmer to select necessary fertilizers which in turn prevents excess use of fertilizers. This will provide a helping hand to the farmers in real-time monitoring, achieving precision agriculture and hence increasing the production by overcoming the problems faced due to lack of proper knowledge about crop's conditions and technical support. Thus, this system limits the problems of wired sensor networks and has the advantage of flexible networking for monitoring equipment, simple installation and removing of equipment, low power consumption, low cost and reliable nodes and high capacity.

Keywords: WSN, Precison agriculture, Crop monitoring, Decision making

I. INTRODUCTION

Nowadays, agriculture needs tools and technology to enhance the efficiency and quality of production and reduce the environmental impact on the crop. This can be achieved by using modern technologies which supports communications, high level computing and control within devices. Wireless sensor networks are an important technology for large-scale monitoring, providing sensor measurements at high temporal and spatial resolution. It helps in distributed data collection, monitoring in harsh environments, precise irrigation and proper quantity of fertilizers to produce best quality of crops.

This paper compares the existing technologies available and also proposes the design and development of a better WSN system which will communicate each other with low power consumption. These wireless sensors are battery or solar energy powered, equipped with wireless radio, storage unit, data processing unit and various sensing units. This system will help farmers to notify favorable conditions for farming and to maintain the records of agricultural environment.

II. LITERATURE REVIEW

In [1] irrigation management system, they are using intelligent humidity sensor and low power wireless Transceiver to collect data and capture SWT which facilitate irrigation. They are using PC/laptop for monitoring purposes. After processing of SWT data, they are predicting the time for irrigation.

In [2] proposed system, the automatic irrigation system is open loop, automatic and adaptive. They are determining the soil moisture and amount of water needed to the crop so that sufficient amount of water is just enough to maintain the soil moisture level. They have used a microcontroller to control the operation along with relay switch and pump.

In paper [3], they have deployed a self-organizing ad-hoc sensor network in vineyard. It collects temperature data and after processing it shows a map of powdery mildew risk to the farmers.

In paper [4], it shows that the position estimation of sensor nodes in WSN for precision agriculture generally includes errors and hence it means that the average value of localization error decreases with the signal propagation coefficient and also proves that the robustness of NMDS (non-metric multi-dimensional scaling) algorithm for bad environment.

In paper [5] [6], they have proposed cluster based routing algorithm to reduce the energy consumption of node transmitting data. In paper [5], they have used WSN based on the acoustic emission principle for crop water stress. In paper [6], a new type of routing protocol for WSN called as PECRP (Power-efficient clustering routing protocol) has been proposed. This is suitable to long-distance and complex data transmission and for fixed sensor nodes of WSN.

The above research papers studied so far, demonstrate the effective use of WSN in agriculture. Many of them have Proposed different ideas to make their system effective and efficient but those ideas are not yet deployed in real field and those who have deployed it that is not suitable for all types of crops. Since every crop has its own requirement, so it is necessary to design and implement by taking requirement of a particular crop and field location into consideration.

III. PROPOSED WORK

This project consists of Arduino, Temperature sensor, Humidity sensor, LCD Display, ZigBee module, Water pump, a fan and a PC for remote monitoring. The sensor readings will be displayed in a LCD. Depending upon the sensor levels, the loads will be activated automatically. For e.g., if the temp reading is high, switch on the dc fan. For humidity, switch on the pump. The sensor values and the status of the loads will be displayed locally in an LCD and remotely in a PC. The sensor data will be sent wirelessly to a remote PC for monitoring. In this project, microcontroller is interfaced with two sensors, ZigBee wireless radio module and PC for remote monitoring. The sensors used are:

Temperature Sensor:

LM35 acts as temperature sensor whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. Microcontroller is interfaced with ADC0809. The ADC converts input analog signal of LM35 (Temperature sensor) to digital signal. Microcontroller gets digital signal from ADC via port1 and the corresponding temperature is found and displayed in LCD. If the temperature value is more than 40 deg C, a dc Fan is ON. The fan is interfaced to the Microcontroller via relay board.

Humidity Sensor:

Humidity sensor is interfaced to the microcontroller via ADC. After digitizing the humidity values, the microcontroller checks for the threshold limit programmed to it. If the soil moisture is found low, it alerts the microcontroller to switch on the respective relay in turn, it switches on the water pump. With the help of the pump, the irrigation land will get water.

ZigBee Wireless Radio module:

In this project, we are using ZigBee transceiver pair, one attached to the sensor side and one on the PC side. The ZigBee attached to the sensor side collects the sensor values and transmits those values to another ZigBee transceiver wirelessly.

Those values will be displayed in the front end of the PC using Visual basic software. The ZigBee radio and the PC are connected through an UART. The board and the PC are connected using Serial port. The sensor values will be observed in a remote PC.

About Microcontroller:

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB Cable or power it with an AC-to-DC adapter or battery to get started.

The Uno can be programmed with the Arduino Software (IDE). Select "Arduino/Genuine Uno" from the Tools > Board menu (according to the microcontroller on your board). The ATmega328 on the Uno comes preprogrammed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically. We have also used solar energy to recharge the battery.

Block Diagram of the Proposed Design:

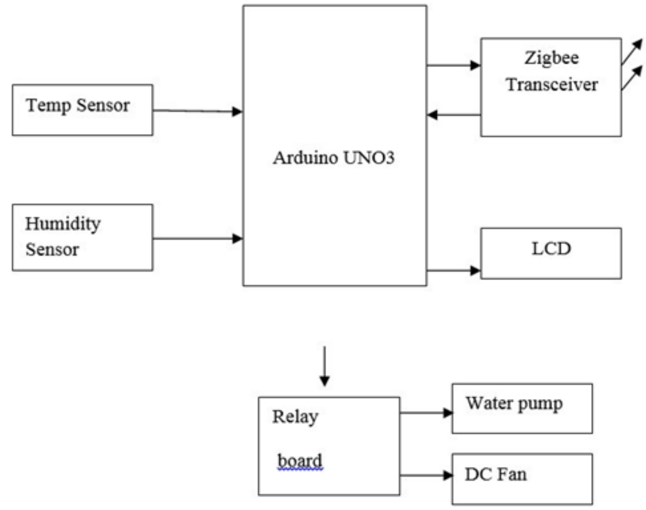

Fig. 1 Block diagram

IV. ANALYSIS SUMMARY

ZigBee is established by the ZigBee Alliance that is supported by more than 70 member companies. It adds network, security and application software to the IEEE 802.15.4 standard. Owing to its low power consumption and simple networking configuration, ZigBee is considered the most promising for wireless sensors. Currently, the ZigBee specification is still under development. **Table 1** compares the three wireless standards that are most suitable for wireless. As it shown in the **Table 1** ZigBee is more suitable for our application.

The ZigBee standard supports three device types: ZigBee Coordinator, ZigBee Router, and ZigBee End Device. Each device type implements varying levels of functionality with associated cost impacts. Thus, equipment manufacturers and system developers may implement network topology and tradeoff functionality with overall cost.

TABLE 1. Comparison between wireless LAN, Bluetooth and ZigBee

Feature	Wi-Fi (IEEE 802.11 b)	Bluetooth(IEEE 802.15.1)	ZigBee (IEEE 802.15.4)
Radio	DSSS[1]	FHSS[2]	DSSS
Data rate	11 Mbps	1 Mbps	250 kbps
Node per master	Up to 3 s	Up to 10 s	30 ms
Range (m)	100	10	70
Data type	Video, audio, graphics, picture, files	audio, graphics, pictures, files	Small data packet
Extendibility	Roaming possible	No	Yes
Battery life	Hours	1week	>1year
Complexity	complex	Very complex	simple

1. Direct sequence spread spectrum; 2. Frequency hopping spread spectrum.

V. SIMULATION RESULT

Figure 2 is a graph that represents environmental data measured by the proposed agricultural environment monitoring server system that is installed to be operational in the real agricultural environment, and it could be seen from this graph that the agricultural environment monitoring server system normally processes information sensed from WSN sensor nodes installed outdoors without malfunction. In addition, according to the power consumption field tests, the agricultural environment monitoring server system could be operated for about 24 hours by charging with the solar cells for about 10 hours, and the proposed system could be operated with only the solar cells installed on the system, without requiring a wired power supply connection or any additional charging process. Figure 3 is a graph that represents the results of the power consumption field test of the proposed system. Through the above results, it could be found that the proposed agricultural environment monitoring server system collects information even in the real outdoors environment without malfunction and provides real-time monitoring and various application services based on the information.

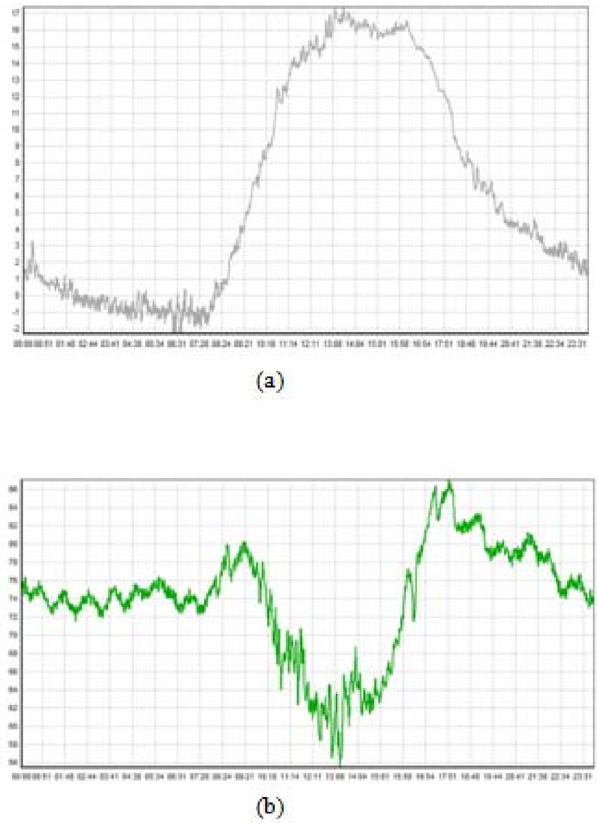

Figure 2. Measured Environmental Data Graph. **(a)** Temperature Graph (2016.03.23); **(b)** Humidity Graph (2016.03.23)

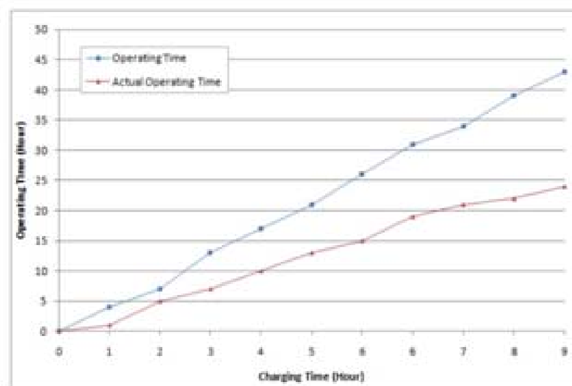

Figure 3. Field Test Result on Power Consumption of the Proposed System

VI. CONCLUSION

Precision agriculture and WSN applications combine an exciting new area of research that will greatly improve quality in agricultural production, precision irrigation and will have dramatic reduction in cost needed. Furthermore, the ease of deployment and system maintenance, monitoring opens the way for the acceptation of WSN systems in precision agriculture. Using the proposed methodology, in finding the optimal sensor topology, we contrive to lower implementation cost and thus make WSN a more appealing solution for all kinds of fields and cultivations. This paper proved potential applications of ZigBee wireless technology in agricultural systems can be ex-tended to real time field monitoring, automated irrigation control, monitoring, and remote operation of field machinery.

VII. FUTURE WORK

The other problem farmers are facing is the crop destruction by the wild animals. So the future work include the design of the system that may monitor the farm by installing sensors at the boundary of farm and a camera module which may take a snapshot once the sensor detects the entrance and transmit the real time pictures by integrating it with other information. Also, the power consumption can be minimized up to some more extent. And, it can be applied based on the distance among the crops.

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