Internet of Things Application for Implementation of Smart Agriculture System

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***Abstract*— Over the past few years, there has been significant interest in designing smart agricultural systems. The use of smart farming techniques can enhance the crop yield, while simultaneously generating more output from the same amount of input. But still, most of the farmers are unaware of the latest technologies and practices. In this paper a novel wireless mobile robot based on Internet of Things (IoT) is designed and implemented for performing various operations on the field. This proposed wireless robot is equipped with various sensors for measuring different environmental parameters. It also includes Raspberry Pi 2 model B hardware for executing the whole process. The main features of this novel intelligent wireless robot is that it can execute tasks such as moisture sensing, scaring birds and animals, spraying pesticides, moving forward or backward and switching ON/OFF electric motor. The robot is fitted with a wireless camera to monitor the activities in real time. The proposed wireless mobile robot has been tested in the fields, readings have been monitored and satisfactory results have been observed, which indicate that this system is very much useful for smart agricultural systems.**

Keywords*— *Sensors, Zigbee, Smart controllers, wireless sensor network, automation, interfacing, and intelligent farming.

I INTRODUCTION

Agriculture is the main source of livelihood of many people in different parts of the world. It is the most important occupation of many families in India. Approximately 60% of the land can be ploughed and used to grow crops such as rice, potato, wheat, onion, tomato, mangoes, sugar cane, bean, cotton, and cereals etc. Unfortunately farmers are still reliant on traditional techniques that have evolved hundreds of years ago. Due to this the yield of crops are becoming low. Also there are a number of factors that contribute to the low yield of crops such as proper soil preparation, seed rate, seed cultivar, different sowing time, lack of moisture in the fields, water logging and salinity, lack of application of fertilizers, plant protection, adoption of modern technologies, improper marketing and lack of investment. Farmers suffer large financial losses because of usage of incorrect irrigation mechanisms, insect pests and attack of plant diseases, usage of uncalculated amount of pesticides and insecticides, and wrong prediction of weather. For getting higher yield on crops, monitoring is the vital task for the farmers. Due to the various constraints involved in agriculture, there is an urgent need to develop enhanced and economically realistic strategies in growing of crops.

The farm irrigation systems in the previous years used simple timers and switches to control the irrigation mechanism for a predetermined time period irrespective of the weather conditions or moisture content present in the soil. By incorporating various advanced sensing and controlling techniques, the crop yield has increased to some extent while simultaneously the labor costs have decreased. However, the major drawback of these techniques are that they are complex in design to fit in the cultivation land and expensive. Thus there is a need for wireless technologies and automation in agriculture farming. Many wireless technologies were used in agriculture field such as remote sensing, global positioning system and geographical information system. Hence wherever automation had been implemented and labor being replaced by automatic machineries, the crop yield has improved significantly. A Wireless Sensor Network (WSN) is a wireless network, in which various sensors are interconnected to monitor physical or surrounding environmental conditions. These WSNs are accepted as powerful networks to collect and process data in the agricultural domain with low cost and low power consumption. They offer a high spatial and temporal resolution to monitor crops through various sensor nodes deployed across the agricultural field, which are connected wirelessly and send data automatically via multi-hop communication [1]. Recent developments in information and computer technology and in wireless sensor networks have made maintaining and functioning of agro-based industries like Greenhouse, Floriculture and Horticulture etc. easier than ever before. The need for intelligent farming has grown to a larger extent in the production of various crops. Recently Internet of Things (IoT) has revolutionized all the major business sectors and industries across the world. IoT involves many things interacting with each other to produce actionable information [2]. An IoT can remotely determine the status and working condition of equipment (closed or open, on or off, full or empty, etc.). IoT technology is allowing farmers to connect various devices to the internet and it has resulted in significant increase in crop yield, reduce waste, better pest control and streamline livestock management.

This paper is organized as follows. Section II presents various works related to the existing system. Section III discusses the design and implementation of the proposed system using Raspberry Pi 2 Model B. The hardware results and discussions are presented in Section IV. Finally, conclusions are drawn in Section V.

II RELATED WORKS

H. Chang *et al* [3] developed a new agriculture monitoring system based on WSNs. Y. Jiber *et al* [4] proposed a precision agriculture monitoring approach that provides meaningful services to farmers. It reports the advantage of the precision agriculture approach to help making valued decisions which could not only increase the land productivity but also optimize the use of various resources. F. G. Costa *et al* [5] describes an architecture based on unmanned aerial vehicles (UAVs) which can be employed to implement a control loop for agricultural applications where UAVs are responsible for spraying important chemicals on crops. The process of applying the chemicals is controlled by means of the feedback obtained from the wireless sensor network deployed on the crop field. The obtained results show that the adjustment of the route based on the feedback information from the sensors could minimize the wastage of pesticides. Stipanicev *et al* [6] describes a networked embedded greenhouse monitoring and control based on simple embedded web servers and connecting sensors and actuators using 1-wire protocol. M. Martinelli *et al* [7] proposed a WSN-based solution for precision farm purposes. Y. Kim *et al* [8] designed a remote sensing and control of an irrigation system using a distributed WSN. In the proposed system communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost bluetooth wireless radio receiver. Graphical user interface-based software has been developed to offer stable remote access to field conditions and real-time control and monitoring of the variable-rate irrigation controller. A. Hanggoro *et al* [9] proposed and designed a greenhouse monitoring and controlling is a complete system designed to monitor and control the humidity inside a green house. It uses an android mobile phone, connected using Wi-Fi to a central server which connects via serial communication to a microcontroller and humidity sensor. S. Jin *et al* [10] developed a remote measurement and control system of large-scale greenhouse based on GSM-SMS. S. O. Al Mehairi *et al* [11] discusses the design and implementation of a prototype system which integrates various existing technologies for home monitoring and control that fits with the future smart home concept. In this work the various devices in the home are connected wirelessly using Bluetooth standard to a home server and can be monitored and controlled via the mobile phone using a portable MIDlet application. J. Gutiérrez *et al* [12] developed an automated irrigation system using a WSN and GPRS module in which an algorithm was developed with different threshold values to control various parameters. Compared to the existing related research works, in this paper, we propose a mobile wireless robot which collects the data from different types of sensors and then send it to main server using wireless protocol. The collected data from various sensors onboard the mobile robot provides the information about different environmental factors around the plants which in turns helps to monitor the entire agricultural field. Monitoring itself is not enough and complete solution to improve the yield of the crops is important. Also there are number of other factors that affect the productivity of crops to a great extent. These factors include attack of insects and pests which can be controlled by spraying the crop with proper insecticide and pesticides. Secondly, attack of wild animals and birds when the crops are in growing stage. This can be avoided by periodically generating a loud creak to scare the birds and mammals from the robot, whenever it senses any unknown object near the fields. There is also possibility of thefts when crop is at the stage of harvesting. So, in order to provide solutions to all such problems, it is essential to develop a wireless integrated system such as novel mobile robot using Raspberry Pi 2 Model B incorporating various sensors.

III DESIGN AND IMPLEMENTATION USING RASPBERRY PI 2 MODEL B

Sensor network nodes are tiny objects which are installed in the different monitoring areas of wireless sensor network, in order to measure various physical data and finish the specified task. Improvement in growth of various crops depends on various environmental parameters such as light intensity, soil moisture, relative humidity, soil temperature, usage of fertilizers and pH of soil etc. Any minor changes in any of these parameters can cause problems like improper growth of crops and formation of diseases in plants etc. which results in lesser crop yield.

The proposed smart agricultural system shown in figure 1 consists of transmitter section (i.e. mobile controlled robot) and the monitoring section. The block diagram of the proposed transmitter section is shown in fig.1. The transmitter section consists of Raspberry Pi 2 Model B, various sensors such as humidity sensor, pH sensor, Thermo

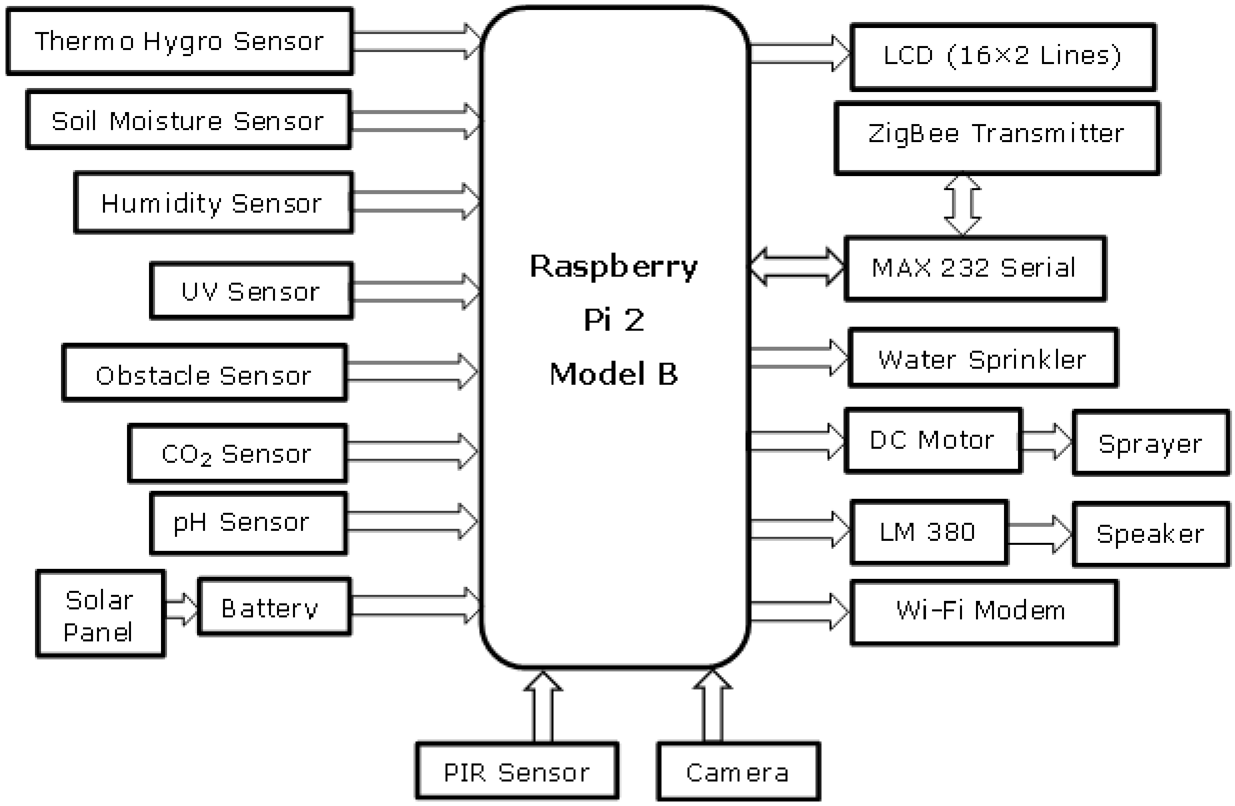

Fig. 1 Implementation of the proposed smart agricultural system

hygro sensor, CO_2 sensor, Soil moisture sensor, Obstacle sensor, Power supply section (i.e. using solar plate), Zigbee transmitter, a Wi-Fi modem, Water sprinkler, DC motor for spraying insecticides, a LM380 audio power amplifier, speaker, Liquid crystal display and Camera. The monitoring section consists of an Android smart phone, Zigbee receiver and a Laptop with application language. The block diagram of monitoring section is shown in fig. 2.

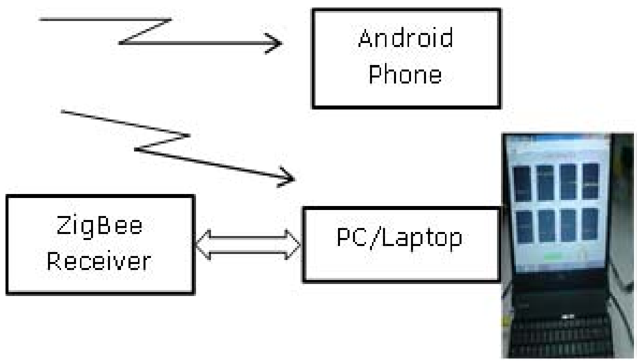

Fig. 2 Monitoring section

The proposed system consists of the following main hardware:

A. RASPBERRY PI 2 MODEL B:

Raspbian is the recommended operating system for use on a Raspberry Pi 2 Model B. It is a free operating system based on Debian, optimized for the Raspberry Pi hardware. It is a low power, high performance controller for interfacing various sensors and performing the required task based on the written program.

B. CO_2 SENSOR:

The CO_2 gas sensor measures the gaseous carbon dioxide levels by observing the amount of infrared radiation absorbed by carbon dioxide molecules. It has two settings: low range (0–10,000) ppm and high range (0–100,000) ppm. Fig. 3 shows a typical CO_2 sensor used in the proposed system.

Fig. 3 CO_2 Gas sensor

G. THERMO HYGRO SENSOR:

The thermo hygro sensor measures the outdoor temperature and humidity and transfers the obtained data to the raspberry pi 2 model B and further the data is transferred to the PC using Zigbee or Wi-FI modem. This sensor is placed under a pad in front of the mobile robot, so as to avoid direct sunlight; otherwise it may result in incorrect readings. Fig. 4 shows a typical thermal hygro sensor used in the proposed system

Fig. 4 Thermo Hygro sensor

H. HUMIDITY SENSOR:

Humidity is the amount of water vapour present in the air. It indicates the exact amount of water vapour present in the air and these values are displayed on LCD. It converts directly relative humidity to voltage. Fig.5 shows a typical humidity sensor used in the proposed system.

Fig. 5 Humidity Sensor

F. MOISTURE SENSOR:

The Moisture Sensor detects the moisture of the soil around the sensor, which is ideal for monitoring the plants or the soil moisture. This sensor uses the two probes to pass current through the soil, and then it reads that resistance to get the moisture level. Excess water makes the soil conduct electricity better; while dry soil conducts electricity poor. Fig. 6, shows a typical moisture sensor used in the proposed system.

Fig. 6 Soil moisture sensor

Fig. 7 pH sensor

G. pH SENSOR:

The pH value of soil is an important factor in determining which crops will grow. Also by monitoring these values carefully, necessary amount of nutrients can be supplied to the plants to have a healthy growth.

H. UV SENSOR:

The ultra violet sensor monitors ultra violet rays and based on the intensity converts photo-current to voltage. It is equipped with an internal amplifier and easily interfaced to external circuits such as analog to digital converter. The UV sensor detects (280-390) nm light most effectively. Fig.8 shows a typical UV sensor used in the proposed system.

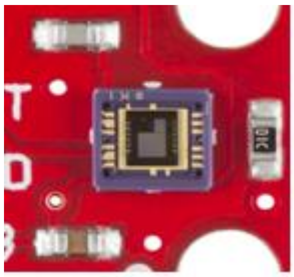

Fig. 8 UV sensor

Fig. 9 PIR sensor

I. PIR SENSOR:

PIR (Passive Infra-Red) sensors are used to detect warm-bodied targets in motion. In this work, if any moving mammals or birds which come near to the crop fields are detected and scarred away from the fields using bird scarer circuit. Fig.9 shows a typical PIR sensor used in the proposed system.

IV HARDWARE IMPLEMENTATION AND RESULTS

In this proposed work, Raspberry Pi 2 Model B is the main controller. All the sensors such as thermo hygro sensor, soil moisture, humidity, ultra violet, CO_2, ultra sonic and pH sensor are interfaced to Raspberry Pi 2 Model B which is located on the wireless mobile robot. Camera is also interfaced to the Raspberry Pi 2 Model B to capture the crop field and to observe the live events occurring on crop fields. The novel wireless robot is remotely controlled using necessary commands from the PC section in the receiver side. Based on the written program, Independent operations such as making the wireless robot move in the correct path whenever the robot experiences an obstacle, giving some strange sounds whenever wireless robot experiences a unknown movement nearby, spraying of pesticides and switching on the electric motor whenever there is shortage of moisture content in the crop fields. Figure 10 and Figure 11 shows the movement of the novel wireless robot in agricultural fields.

Fig. 10 Robot Changing its direction because of obstruction in fields

Fig. 11 Movement of robot

Table 1 shows various important sensor readings monitored from the agricultural field at different time intervals.

Table 1: Various sensor readings monitored from the field

S.No:	Date and Time	Temperature in °C	Humidity in %	Moisture in mV
1	18-12-2016 09:00:00AM	22.2	53	98
2	18-12-2016 09:12:00AM	22.9	53	97
3	18-12-2016 09:28:00AM	23.4	52	94
4	18-12-2016 09:39:00AM	24.3	49	89
5	18-12-2016 09:56:00AM	24.7	48	87
6	18-12-2016 10:05:00AM	26.2	47	86
7	18-12-2016 10:22:40AM	27.5	47	86
8	18-12-2016 10:30:34AM	28.3	44	84
9	18-12-2016 10:43:24AM	29.3	42	83
10	18-12-2016 10:59:13AM	30.1	41	81
11	18-12-2016 11:13:29AM	31.3	41	81
12	18-12-2016 11:31:45AM	33.8	39	78
13	18-12-2016 11:42:16AM	35.6	36	76
14	18-12-2016 11:54:19AM	36.9	35	75
15	18-12-2016 12:22:50PM	38.4	32	72
16	18-12-2016 01:07:33PM	34.6	41	79
17	18-12-2016 01:34:05PM	32.8	43	81
18	18-12-2016 01:55:10PM	31.3	46	84
19	18-12-2016 02:13:10PM	34.7	48	88
20	18-12-2016 02:28:10PM	37.2	49	92
21	18-12-2016 03:15:17PM	33.5	39	86
22	18-12-2016 03:48:50PM	32.3	44	94
23	18-12-2016 04:32:40PM	31.4	47	92
24	18-12-2016 04:53:46PM	29.8	53	96

The output data from various sensors are recorded in Table 1 and plotted in figures 12, 13 and 14.

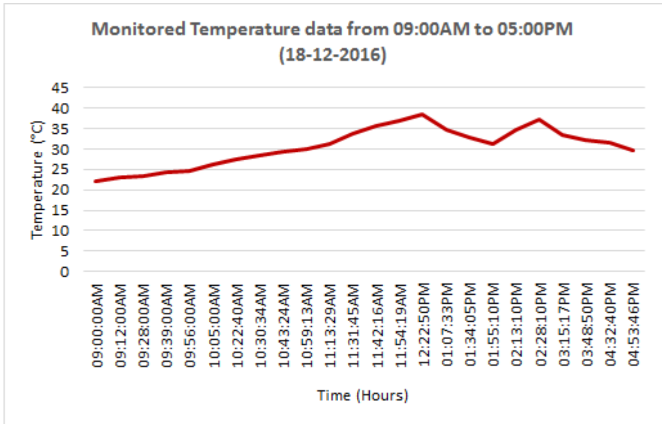

Fig. 12 Monitored data from Thermo Hygro sensor

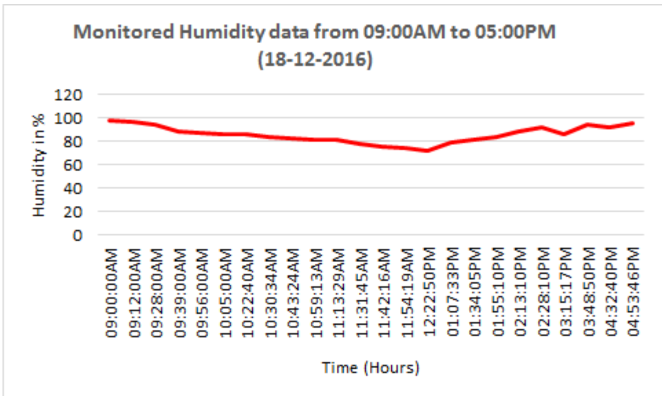

Fig. 13 Monitored data from Humidity sensor

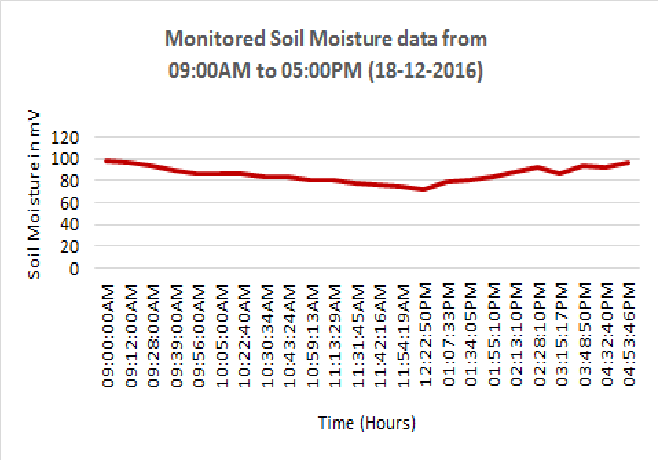

Fig. 14 Monitored data from Soil Moisture sensor

V CONCLUSIONS

In this paper, design and implementation of a novel wireless mobile robot is designed and implemented. It is equipped with various sensors to monitor different environmental parameters that are suitable for crop yield. Monitoring of crops wirelessly allows reducing labor costs and also helps to track the changes accurately occurring instantly in real time at the field. The proposed system is capable of controlling the essential parameters necessary for plant growth. So this proposed smart agricultural system of farming is user-friendly and highly robust.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, A survey on sensor networks, IEEE Communications Magazine 40 (8) (2002) 104–112.

[2] L. Atzori, A. Iera, and G. Morabito, "The Internet of Things: A survey," Computer Networks, vol. 54, pp. 2787-2805, 10/28/ 2010.

[3] H. Chang, N. Zhou, X. Zhao, Q. Cao, M. Tan and Y. Zhang, "A new agriculture monitoring system based on WSNs," 2014 12th International Conference on Signal Processing (ICSP), Hangzhou, 2014, pp. 1755-1760.

[4] Y. Jiber, H. Harroud and A. Karmouch, "Precision agriculture monitoring framework based on WSN," 2011 7th International Wireless Communications and Mobile Computing Conference, Istanbul, 2011, pp. 2015-2020.

[5] F. G. Costa, J. Ueyama, T. Braun, G. Pessin, F. S. Osório and P. A. Vargas, "The use of unmanned aerial vehicles and wireless sensor network in agricultural applications," 2012 IEEE International Geoscience and Remote Sensing Symposium, Munich, 2012, pp. 5045-5048.

[6] Stipanicev, D.; Marasovic, J., "Networked embedded greenhouse monitoring and control," in Control Applications, 2003. CCA 2003. Proceedings of 2003 IEEE Conference on, vol.2, no., pp.(1350-1355) vol.2, (23-25) June 2003.

[7] M. Martinelli, L. Ioriatti, F. Viani, M. Benedetti and A. Massa, "A WSN-based solution for precision farm purposes," 2009 IEEE International Geoscience and Remote Sensing Symposium, Cape Town, 2009, pp. V-469-V-472.

[8] Y. Kim, R. G. Evans and W. M. Iversen, "Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network," in IEEE Transactions on Instrumentation and Measurement, vol. 57, no. 7, pp. 1379-1387, July 2008.

[9] A. Hanggoro, M. A. Putra, R. Reynaldo and R. F. Sari, "Green house monitoring and controlling using Android mobile application," 2013 International Conference on QiR, Yogyakarta, 2013, pp. 79-85.

[10] S. Jin, S. Jingling, H. Qiuyan, W. Shengde and Y. Yan, "A Remote Measurement and Control System for Greenhouse Based on GSM-SMS," 2007 8th International Conference on Electronic Measurement and Instruments, Xi'an, 2007, pp. 2-82-2-85.

[11] S. O. Al Mehairi, H. Barada and M. Al Qutayri, "Integration of Technologies for Smart Home Application," 2007 IEEE/ACS International Conference on Computer Systems and Applications, Amman, 2007, pp. 241-246.

[12] J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay and M. Á. Porta-Gándara, "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module," in IEEE Transactions on Instrumentation and Measurement, vol. 63, no. 1, pp. 166-176, Jan. 2014.