IMPLEMENTATION OF A WIRELESS MOBILE ROBOT FOR INTELLIGENT FARMING

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ABSTRACT:

Over the past few years, there has been significant awareness in designing intelligent robotic devices for use in external outdoor environments, which can independently sense, analyze and react to their own surroundings. The agricultural sector is already experiencing enormous challenges such as limited availability of arable lands, increasing requirement of water resources, and variation in climatic conditions. Also due to the recent advances in computer and related technologies, still the farmers are not adapted to those technologies as they are neither poorly managed nor designed for their particular needs. One method to address these various issues is to develop sensing technology to make agricultural farms more intelligent. In this paper a novel wireless mobile robot using ARM7 microcontroller is designed and implemented for carrying out various operations on the field. This proposed wireless mobile robot is equipped with various sensors for measuring different environmental parameters. The main features of this novel intelligent mobile 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 acceptable results have been observed, which indicate that this system is very much useful for intelligent farming.

Keywords— Sensors, Climate change, Embedded System, Wireless Mobile robots, Internet, Zigbee, Smart controllers, wireless sensor network, automation and interfacing.

I INTRODUCTION

Agricultural farming is the key source of occupation of many people living in different parts of the world. It is the most important livelihood of many families in India. Roughly about 65% of the land can be cultivated and used to grow various crops such as rice, wheat, potato, bean, onion, tomato, mangoes, sugar cane, cotton, and cereals etc. Unfortunately farmers are still dependent on traditional farming techniques that have originated 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 improper soil preparation, low 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 methods, insect pests on the field and attack of plant diseases, usage of uncalculated amount of pesticides and insecticides, and wrong prediction of weather. Also farmers are unaware about the exact conditions of weather. They have their own approaches in sowing the seeds, water-ing the fields, usage of pesticides and harvesting the final crops. Farmers personally go to the different parts of their farming land and monitor the crops. 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 different crops.

The farm irrigation systems in the earlier years utilized simple clocks and buttons to control the irrigation mechanism for a scheduled time period irrespective of the weather conditions present around the fields 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 very 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. So due to the advances in computer technologies, the traditional agricultural system has been converted into a digital agricultural system.

A Wireless Sensor Network (WSN) is a wireless network system, in which numerous sensors are interconnected to observe the physical or surrounding environmental conditions. These WSNs are recognized 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]. Due to the recent advances in wireless sensor networking technologies, low power, multi-functional and low cost sensor nodes have been developed and available in the market. Different sensor nodes sense different physical parameters of the surrounding environment and process the data. Monitoring of agricultural fields wirelessly permits the user to see accurate changes happening on the fields and also it reduces the usage of labor cost. The need for intelligent farming has grown to a larger extent in the production of various crops. Over the past decade, wireless technologies have modernized all the major business sectors and industries across the world.

Wireless technology is allowing farmers to interconnect various sensors to the main controller and it has resulted in significant increase in crop yield, reduce waste, better pest control and streamline livestock management.

This paper is prepared as follows. Section II presents various works related to the existing system. Section III shows the design and implementation of the proposed system using ARM 7 LPC2148 processor. The hardware results and discussions are presented in Section IV. Finally, some conclusions are drawn in Section V.

II RELATED WORKS

Ross *et al.,* [2] described a novel obstacle detection system for autonomous robots in agricultural field environments. It uses a novel detector to inform stereo matching and estimates the probability density in image descriptor space and incorporates image-space positional understanding to identify potential regions for obstacle detection using dense stereo matching. Soyer *et al.,* [3] designed a mobile robot having a biologically motivated vision system. This robot is designed to have both physical, mental attention capabilities and end selective perceptual processing capabilities; thus, it can be used in real-time behavior applications. Blender *et al.,* [4] discussed on the architecture and function of OptiVisor within the overall mobile agricultural robot swarm system. This OptiVisor in combination with a simulation environ-ment for a robot swarm is presented and shows the feasibility of the general concept and the current state of the algorithms. Durmus *et al.,* [5] developed a mobile autonomous robot which has the capability of processing and monitoring field operations like spraying remedies for precision farming, fertilization, disease diagnosis, yield analysis, soil analysis and other agricultural activities. This proposed robot has the capability to communicate to environmental agriculture informatics applied research center cloud services and application software will be able to transfer data to farmers' mobile devices, tractors and farming vehicles. Michaels *et al.,* [6] presented a novel autonomous and mobile manipulated agricultural robot for weeding. Techniques such as high speed image processing and visual servoing are applied to precisely position a specially designed weeding tool. The entire system is evaluated by running the mobile test vehicle in field-like conditions and demonstrated that the system can weed single plant in less than 1second. Ko *et al* [7] designed, fabricated and demonstrated a mobile robotic platform for agricultural application namely pesticide spraying. The design and development comprises synergistic integration of mechanical, sensor and actuator, navigational and control, and electronic and software interfacings. Corpe *et al.,* [8] presented a paper that describes the development of a modular mobile robot platform that is designed to provide agricultural industries with improved capabilities around managing land and the plants/animals that are held on it. It uses global positioning system to provide the local positioning for the robot. A prototype robot was developed using a Navman GPS module. The results indicate that the robot system can record a travelled path within a field and then re-navigating that path within the specified accuracies of the GPS module. Nakamura *et al.,* [9] reports the design and development of rice field weeding robot that has automatic weeding capability in actual rice fields.

Currently food prices have increased, because of lack of man power, increased cost of production and increased labor wages. In order to solve problems related to man power and increased wages, a novel mobile robot is implemented using wireless technology. Compared to the existing related research works, in this paper, a wireless mobile robot is proposed. Different types of sensors are fitted with this mobile robot to collect the various physical parameters related to the environment. The collected data from various sensors onboard the mobile robot provides the information about various environmental factors around the plants which in turns helps to monitor the entire agricultural field. Monitoring itself is not sufficient and complete solution to improve the yield of the crops is of utmost important. Also there are number of other key factors that affect the production 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. So, in order to provide solutions to all such problems, it is essential to develop an integrated system such as novel wireless mobile robot using ARM 7 processor incorporating various sensors. This mobile robot operates in synchronization with various sensors to accomplish intelligent farming.

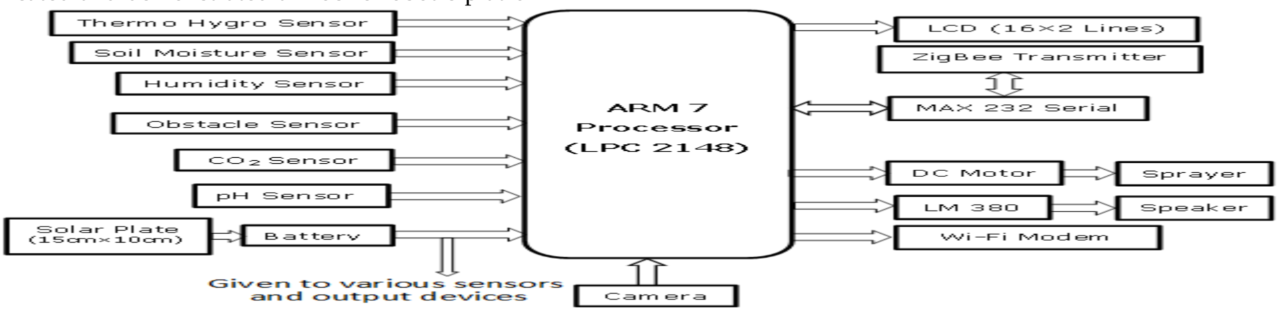

Fig. 1 Block diagram of the proposed wireless mobile robot

III DESIGN AND IMPLEMENTATION USING MICROCONTROLLER

In this paper, the design and development of an automated agricultural system based on microcontrollers and wireless communication technologies at investigational level within rural areas is presented. The objective of the implementation was to demonstrate that the wireless mobile robot can be used to sense various on field physical parameters and appropriate action can be taken automatically based on the program written by the user. The monitored data from the sensors are simultaneously transmitted to a receiver which is located at a remote place. The whole implementation is solar powered with necessary battery backup. The mobile robot automatically performs necessary operations when threshold values of various sensors are reached. The communication between the ARM 7 and the receiver side is via the Zigbee protocol under IEEE802.15.4WPAN. The internet connection to computer at the receiver side allows the inspection of environmental data in real time on a website, where the soil moisture, temperature levels, humidity and light levels are graphically displayed through an application interface and stored in a database server. This access also permits direct programming of scheduled events according to the crop yield and season management. Because the entire developed system is energy efficient and cost effective, the proposed system can be implemented in geographi-cally isolated areas where human movement is less.

The proposed system shown in figure 1 consists of transmitter section (i.e. mobile controlled robot) and the monitoring section. The transmitter section consists of microcontroller (LPC2148), various sensors such as humidity sensor, pH sensor, thermo hygro sensor, CO_2 sensor, Soil moisture sensor, Obstacle sensor, Power supply section (i.e. using solar plate), Zigbee transmitter, a Wi-Fi modem, DC motor for spraying insecticides, a LM380 audio power amplifier, buzzer, 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 figure 2.

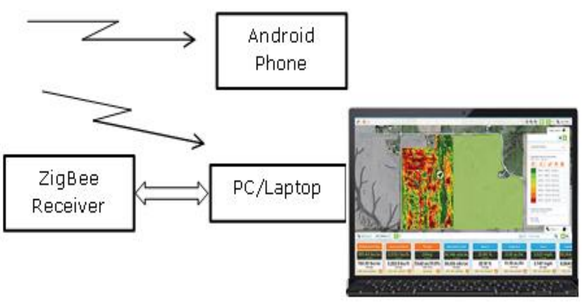

Fig. 2 View of the Monitoring section

MICROCONTROLLER:

The ARM7 is a general purpose 32-bit microcontroller, which offers great performance and draws very less power.

It is extremely tiny in size and is ideal for applications where low power is a key requirement. ARM7 is a versatile processor specially designed for various mobile devices. It supports both 32-bit and 16-bit instructions using Thumb and ARM instruction sets. The ARM7 processor is capable of executing upto 130MIPS on 0.13µm digital CMOS process. Pipelined techniques are employed so that all parts of the processing and memory systems can operate simultaneously. Typically, while one instruction is being executed and completed, its successor is being decoded, and a third instruction is being fetched from memory.

A. CO_2 SENSOR:

For plants to grow healthier and bigger, monitoring carbon dioxide levels is very important. The CO_2 gas sensor measures the gaseous carbon dioxide levels in the surrounding environment by observing the amount of infrared radiation absorbed by carbon dioxide molecules. It is based on infrared LED and detector technology. The sensing method used is the Non-dispersive infrared absorption and has an measurement accuracy of ±70 ppm +/- 5% of reading. It has two settings: low range (0–10,000) ppm and high range (0–100,000) ppm. Figure 3, shows a typical CO_2 sensor used in the proposed system.

Fig. 3 CO_2 Gas sensor

B. OBSTACLE SENSOR:

The ultrasonic sensor transmits signals at a particular frequency and simultaneously receives them with a small delay. The same is used for transmitting and receiving. It is mainly used for distance measurement with a detecting range between 10cm to 4m. Figure 4, shows a typical ultrasonic sensor used in the proposed system.

Fig. 4 Ultrasonic sensor

C. 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 poor electricity. Figure 5, shows a typical moisture sensor used in the proposed system.

Fig. 5 Soil moisture sensor

Fig. 6 pH sensor

D. 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. Figure 6, shows a typical pH sensor used in the proposed system.

IV HARDWARE IMPLEMENTATION AND RESULTS

In this proposed work, ARM LPC 2148 is the main controller. All the sensors such as thermohygro sensor, soil moisture, humidity, obstacle, CO_2, and pH sensors are interfaced to ARM LPC 2148 which is located on the wireless mobile robot. Camera is also interfaced to the mobile robot to capture the live events occurring at the crop field. The novel wireless robot is remotely controlled using necessary instructions from the laptop or through mobile at 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 7 and Figure 8 shows the movement of the novel wireless robot in crop fields.

Fig. 7 Movement of robot in the fields

Fig. 8 Movement of robot

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

Table 1: Various sensor readings observed on the field

S.No:	Date and Time	Temperature in °C	Humidity in %	Moisture in mV
1	29/01/2017 08:00:00AM	14.5	94	143
2	29/01/2017 08:22:00AM	16.8	91	120
3	29/01/2017 08:53:00AM	19.2	90	115
4	29/01/2017 09:09:34AM	20.4	86	112
5	29/01/2017 09:36:15AM	21.7	85	103
6	29/01/2017 09:55:45AM	22.5	81	96
7	29/01/2017 10:04:40AM	26.4	77	92
8	29/01/2017 10:27:54AM	27.9	75	81
9	29/01/2017 10:48:14AM	28.5	73	73
10	29/01/2017 10:56:11AM	30.6	68	64
11	29/01/2017 11:21:22AM	31.3	65	51
12	29/01/2017 11:33:55AM	33.8	62	41
13	29/01/2017 11:56:18AM	35.6	61	132
14	29/01/2017 12:07:18PM	36.9	60	126
15	29/01/2017 12:32:20PM	38.4	59	123
16	29/01/2017 12:56:33PM	39.8	56	113
17	29/01/2017 01:21:35PM	41.4	54	107
18	29/01/2017 01:45:16PM	41.1	53	98
19	29/01/2017 02:06:30PM	39.7	52	95
20	29/01/2017 03:38:40PM	36.4	59	88
21	29/01/2017 03:55:12PM	31.7	61	82
22	29/01/2017 04:08:10PM	27.3	69	75
23	29/01/2017 04:34:49PM	25.6	75	69
24	29/01/2017 04:56:16PM	23.8	82	64

The output data from various sensors are plotted in figure 9, 10 and 11.

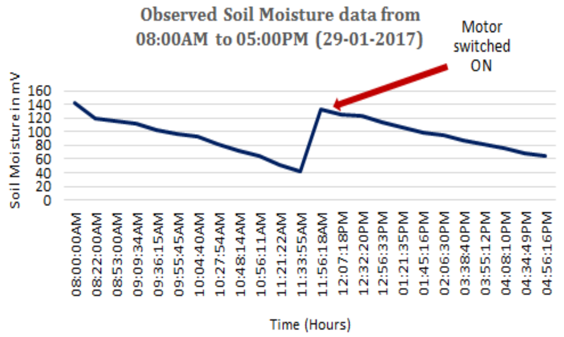

Fig. 9 Monitored data from Soil Moisture sensor

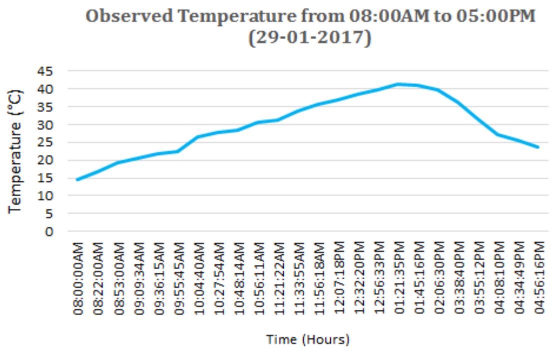

Fig. 10 Monitored data from Thermo-Hygro sensor

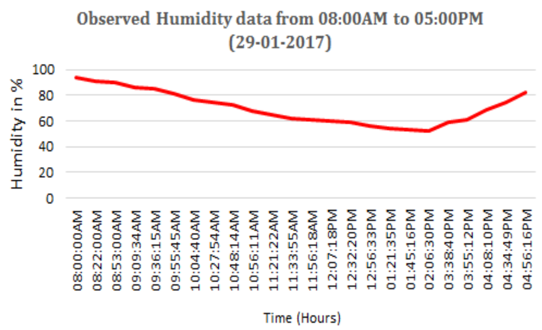

Fig. 11 Monitored data from Humidity sensor

V CONCLUSIONS

In this paper, a wireless mobile robot for intelligent farming is designed and implemented. It utilizes Zigbee protocol under IEEE802.15.4WPAN. This automated wireless mobile robot is used to enhance crop growth and flourish the cultivation of crops. This can be done by the efficiently monitoring the environmental conditions as well as the agricultural factors necessary for growing the crops. Real time monitoring of various environmental parameters provides accurate information related to the crop and soil status and thereby gives an idea for taking necessary steps to improve the crop production. The received data was stored in a database for future analysis to help users discover the best method for cultivation of crops.

In this proposed system, a prototype model is designed and implemented and its functionality has been verified by retrieving the data from sensors, transmitting these measured data through a gateway and storing and analyzing the data on a web server. Further the results are made accessible to the user via a web interface. The proposed system is capable of controlling the essential parameters necessary for crop growth and further the developed system is energy efficient, feasible, highly reliable and cost effective.

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