INTERNATIONAL JOURNAL OF RESEARCH AND DEVELOPMENT IN ENGINEERING SCIENCES
e-ISSN: 2582 - 4201 Volume: 1 | Issue: 1 | Year: 2019

Smart Agriculture using Internet of Things

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Abstract- *Agriculture plays huge role in the continuously development of agricultural country. In our India about 70% of population depends upon farming and one third (1/3) of the nation's capital comes from agriculture services and farming. Various issues concerning agriculture have been always hindering the development of the country. I hope these problems comes main solution to this problem is smart agriculture by modernizing the current traditional methods of agriculture. Hence in the project aims at making agriculture smart using automation and Internet of Things (IoT) technologies. The highlighting and mainly focusing features of this project includes smart GPS based remote controlled robot to perform tasks like weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. Secondly it includes smart irrigation with smart control and smart intelligent decision making based on accurate real time field data. Thirdly, smart warehouse management which includes temperature controlling and maintenance, humidity maintenance and theft detection in the warehouse. Controlling of all these providing operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, Wi-Fi or ZigBee modules, Temperature sensors, camera and actuators with micro-controller and raspberry pi.*

The main aim of this paper is to collect data from multiple locations in a farm. This data will be available to the farmers via the cloud service. This data can be accessed through a mobile application. Not only providing data graphically, the mobile app will also provide numerous services beneficial for the farmers. This paper focuses on remote monitoring system for agricultural industry combined with some farmer friendly applications. The main aim is to collect the readings from multiple nodes and help the farmers handle various operations wirelessly providing a smart agricultural field for smart farmers

Keywords: IoT, Sensors, GPS, automation, ZigBee, Wi-Fi

1. INTRODUCTION

Agriculture is the foundation of the Indian economy, the development of agricultural industry is good for the entire nation and this can help to improve economy steadily. Using IoT(Internet of Things) in the field of agriculture can boost the yield. The Indian farmers use traditional methods for farming. The use of IOT in farming will help increase the yield as well as beneficial for the farmers [1].

Agriculture is considered as the basis of life for the human species as it is the main source of food grains and other raw materials. It plays vital role in the growth of country's economy. It also provides large ample employment opportunities to the people. Growth in agricultural sector is necessary for the development of economic condition of the country. Unfortunately, many farmers still use the traditional methods of farming which results in low yielding of crops and fruits. But wherever automation had been implemented and human beings had been replaced by automatic machineries, the yield has been improved.

Hence there is need to implement modern science and technology in the agriculture sector for increasing the yield. Most of the papers signifies the use of wireless sensor network which collects the data from different types of sensors and then send it to main server using wireless protocol [2]. The collected data provides the information about different environmental factors which in turns helps to monitor the system. Monitoring environmental factors is not enough and complete solution to improve the yield of the crops. There are number of other factors that affect the productivity to 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 crop grows up. There is also possibility of thefts when crop is at the stage of harvesting. Even after harvesting, farmers also face problems in storage of harvested crop. So, in order to provide solutions to all such problems, it is necessary to develop integrated system which will take care of all factors affecting the productivity in every stages like; cultivation, harvesting and post harvesting storage. This paper therefore proposes a system which is useful in monitoring the field data as well as controlling the field operations which provides the flexibility.

The paper aims at making agriculture smart using automation and IoT technologies. The highlighting features of this paper includes smart GPS based remote controlled robot to perform tasks like; weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. Secondly, it includes smart irrigation with smart control based on real time field data. Thirdly, smart warehouse management which includes; temperature maintenance, humidity maintenance and theft detection in the warehouse. Controlling of all these operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, Wi-Fi or ZigBee modules, camera and actuators with micro-controller and raspberry pi.

2. LITERATURE REVIEW

Agriculture is the major source of income for the largest population in many countries and is major contributor to the country's economy. However technological involvement and its usability still have to be grown and cultivated for agro sector in India. Some initiatives have also been taken by the respective Governments by providing online and mobile messaging services to farmer related to agricultural queries, agro vendor information to farmers; it provides static data related to soil quality at each region. The system has not been implemented which can utilizes real time data of soil quality based on its current properties. Soil properties determine the quality of soil. Also health of soil can be maintained by applying only required amount of fertilizers with the help of real time monitoring. Soil moisture analysis helps to supply the water whenever necessary avoiding wastage of water [3].

Also environmental conditions such as temperature and moisture also affect the crop production and crop diseases. In this respect we need a dynamic model which collects such real time data. To increase the production and ease the distribution of agricultural products all agriculture entities need to be connected to have decision making system from farmers to marketing agencies and from vendors to farmers. Such system will also be responsible for controlling other parameters like agro product rates.

The newer scenario of decreasing water tables, drying up of rivers and tanks, unpredictable environment present an urgent need of proper utilization of water. To cope up with this use of temperature and moisture sensor at suitable locations for monitoring of crops is implemented in. An algorithm developed with threshold values of temperature and soil moisture can be programmed into a microcontroller-based gateway to control water quantity. The system can be powered by photovoltaic panels and can have a duplex communication link based on a cellular-Internet interface that allows data inspection and irrigation scheduling to be programmed through a web page.

The technological development in Wireless Sensor Networks made it possible to use in monitoring and control of greenhouse parameter in precision agriculture. After the research in the agricultural field, researchers found that the yield of agriculture is decreasing day by day. However, use of technology in the field of agriculture plays important role in increasing the production as well as in reducing the extra man power efforts. Some of the research attempts are done for betterment of farmers which provides the systems that use technologies helpful for increasing the agricultural yield.

A remote sensing and control irrigation system using distributed wireless sensor network aiming for variable rate irrigation, real time in field sensing, controlling of a site specific precision linear move irrigation system to maximize the productivity with minimal use of water was developed by Y. Kim. The system described details about the design and instrumentation of variable rate irrigation, wireless sensor network and real time in field sensing and control by using appropriate software. The whole system was developed using five in field sensor stations which collects the data and send it to the base station using global positioning system (GPS) where necessary action was taken for controlling irrigation according to the database available with the system. The system provides a promising low cost wireless solution as well as remote controlling for precision irrigation [4].

In the studies related to wireless sensor network, researchers measured soil related parameters such as temperature and humidity. Sensors were placed below the soil which communicates with relay nodes by the use of effective communication protocol providing very low duty cycle and hence increasing the life time of soil monitoring system. The system was developed using microcontroller, universal asynchronous receiver transmitter (UART) interface and sensors while the transmission was done by hourly sampling and buffering the data, transmit it and then checking the status messages. The drawbacks of the system were its cost and deployment of sensor under the soil which causes attenuation of radio frequency (RF) signals.

Internet of Things (IOT):

IoT is a network of Internet enabled objects; web services interact with these objects. It is a technology where objects around us will be able to connect to each other in the system. The IoT will create a world where all the objects are connected to the Internet and communicate with each other with minimum human intervention to optimize use of resources to increase the quality of services offered to people and minimize the operational costs of the services. In this paper IOT will be taken as a measure to help in the increase of yield of the crops. Here, the development of intelligence based systems for the farming sector has to concentrate.

The system monitors and alerts based on IOT with real time monitoring environmental parameters, which, is aimed at monitoring and managing the growth of crops in the farm. It includes mobile inspection device, data receiving devices, data acquisition units, data storage servers. So, the system can automatically collect environmental parameters such as air temperature, air humidity and soil moisture, etc from the environment. It automatically judges the parameters and presents a graphical reading for the users to understand the requirement of the parameters. This will also enable the farmers to control the different devices using the mobile application [5].

2. RELATED WORK

The paper consist of four sections; node1, node2, node3 and PC or mobile app to control system. In the present system, every node is integration with different sensors and devices and they are interconnected to one central server via wireless communication modules. The server sends and receives information from user end using internet connectivity. There are two modes of operation of the system; auto mode and manual mode. In auto mode system takes its own decisions and controls the installed devices whereas in manual mode user can control the operations of system using android app or PC commands [6].

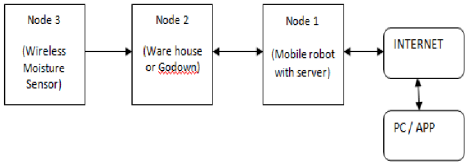

Figure 1: System overview

Challenges in Agriculture industrial sector

- Deficient production information.
- Less knowledge about the weather forecast.
- Not enough sales distribution information.
- Poor ICT (Information and Communication Technology) infrastructure and ICT illiteracy.
- Lack of awareness among farmers about the benefits of ICT in agriculture.
- Marketing research skills and research centre.
- Drastic changes in the climatic conditions
- Lack of interest in agriculture profession among young and educated professionals.
- High cost machineries for work.
- More manual work.
- Keeping a track of record manually.

3. PROPOSED SYSTEM

The proposed system is applying the concept of IOT in the agriculture field by using smart sensors to make agriculture field a smarter one. The basic aim of the project is to collect data from multiple nodes and to process this data. The farmers will be able to control the operations remotely through a mobile application as well as access the readings through a cloud. The purpose of the system is to develop centralize monitoring and control for the agriculture land. This can be managed and functioned from any location wirelessly using a mobile device [7].

The application user can control basic operations of collection of environmental, soil, fertilization, and irrigation data; automatically correlate such data and filter -out invalid data from the perspective of assessing crop performance; and compute crop forecasts and personalized crop recommendations for any particular farm using the application.

Architecture of the system

Node 1: Node1 is GPS based mobile robot which can be controlled remotely using computer as well as it can be programmed so as to navigate autonomously within the boundary of field using the co-ordinates given by GPS module.The Remote controlled robot have various sensors and devices like camera, obstacle sensor, siren, cutter, sprayer and using them it will perform tasks like; Keeping vigilance, Bird and animal scaring, Weeding, and Spraying

Node 2: Node2 will be the warehouse. It consists of motion detector, light sensor, humidity sensor, temperature sensor, room heater, cooling fan altogether interfaced with AVR microcontroller. Motion detector will detect the motion in the room when security mode will be ON and on detection of motion, it will send the alert signal to user via Raspberry pi and thus providing theft detection.

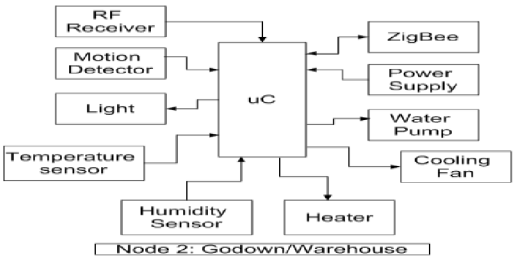

Figure 2: Node 1

Temperature sensor and Humidity sensor senses the temperature and humidity respectively and if the value crosses the threshold then room heater or cooling fan will be switched ON/OFF automatically providing temperature and humidity maintenance.Node2 will also controls water pump depending upon the soil moisture data sent by node3.

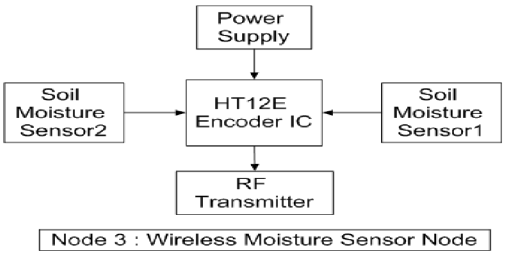

Figure 3: Node 2

Node 3: Node3 is a smart irrigation node with features like; Smart control of water pump based on real time field data i.e. automatically turning on/off the pump after attaining the required soil moisture level in auto mode, switching water pump on/off remotely via mobile or computer in manual mode, and continuous monitoring of soil moisture.

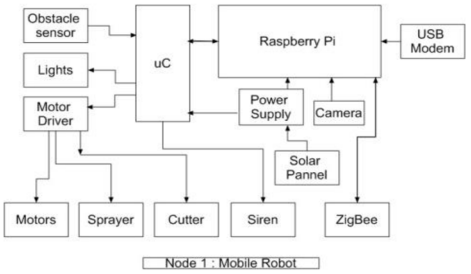

Figure 4: Node 3

In node3, moisture sensor transmits the data using HT12E Encoder IC and a RF transmitter. The transmitted data is received by node2 and there it is processed by microcontroller in order to control the operation of water pump [8].

Hardware used:

a) **AVR Microcontroller Atmega 16/32:** The microcontroller used is, Low-power AVR® 8-bit Microcontroller, having 8K Bytes of In-System Self-programmable Flash program memory, Programmable Serial USART, 8-channel, 10-bit ADC, 23 Programmable I/O Lines.

b) **ZigBee Module:** ZigBee is used for achieving wireless communication between Node1 and Node2. The range for Zigbee is roughly 50 meters and it can be increased using high power modules or by using network of modules. It operates on 2.4 GHz frequency. Its power consumption is very low and it is less expensive as compared to other wireless modules like Wi-Fi or Bluetooth. It is usually used to establish wireless local area networks.

c) **Temperature Sensor LM35:** The LM35 is precision IC temperature sensor. Output voltage of LM35 is directly proportional to the Centigrade/Celsius of temperature. The LM35 does not need external calibration or trimming to provide accurate temperature range. It is very low cost sensor. It has low output impedance and linear output. The operating temperature range for LM35 is −55° to +150°C. With rise in temperature, the output voltage of the sensor increases linearly and the value of voltage is given to the microcontroller which is multiplied by the conversion factor in order to give the value of actual temperature.

d) **Moisture sensor:** Soil moisture sensor measures the water content in soil. It uses the property of the electrical resistance of the soil. The relationship among the measured property and soil moisture is calibrated and it may vary depending on environmental factors such as temperature, soil type, or electric conductivity. Here, It is used to sense the moisture in field and transfer it to microcontroller in order to take controlling action of switching water pump ON/OFF.

Humidity sensor:

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It gives out digital value and hence there is no need to use conversion algorithm at ADC of the microcontroller and hence we can give its output directly to data pin instead of ADC. It has a capacitive sensor for measuring humidity. The only real shortcoming of this sensor is that one can only get new data from it only after every 2 seconds [9].

a) **Obstacle sensor (Ultra-Sonic):** The ultra-sonic sensor operates on the principle of sound waves and their reflection property. It has two parts; ultra-sonic transmitter and ultra-sonic receiver. Transmitter transmits the 40 KHz sound wave and receiver receives the reflected 40 KHz wave and on its reception, it sends the electrical signal to the microcontroller. The speed of sound in air is already known.

Hence from time required to receive back the transmitted sound wave, the distance of obstacle is calculated. Here, it is used for obstacle detection in case of mobile robot and as a motion detector in ware house for preventing thefts. The ultra-sonic sensor enables the robot to detect and avoid obstacles and also to measure the distance from the obstacle. The range of operation of ultra-sonic sensor is 10 cm to 30 cm.

b) **Raspberry Pi :** The Raspberry Pi is small pocket size computer used to do small computing and networking operations. It is the main element in the field of internet of things. It provides access to the internet and hence the connection of automation system with remote location controlling device becomes possible. Raspberry Pi is available in various versions. Here, model Pi 2 model B is used and it has quad-core ARM Cortex-A53 CPU of 900 MHz, and RAM of 1GB. it also has: 40 GPIO pins, Full HDMI port, 4 USB ports, Ethernet port, 3.5mm audio jack, video Camera interface (CSI), the Display interface (DSI), and Micro SD card slot.

Software used:

i. **AVR Studio Version 4:** It is used to write, build, compile and debug the embedded c program codes which are needed to be burned in the microcontroller in order to perform desired operations. This software directly provides .hex file which can be easily burned into the microcontroller.

ii. **Proteus 8 Simulator:** Proteus 8 is one of the best simulation software for various circuit designs of microcontroller. It has almost all microcontrollers and electronic components readily available in it and hence it is widely used simulator. It can be used to test programs and embedded designs for electronics before actual hardware testing. The simulation of programming of microcontroller can also be done in Proteus. Simulation avoids the risk of damaging hardware due to wrong design.

iii. **Dip Trace:** Dip race is EDA / CAD software for creating schematic diagrams and printed circuit boards. The developers provide multi-lingual interface and tutorials (currently available in English and 21 other languages). Dip Trace has 4 modules: Schematic Capture Editor, PCB Layout Editor with built-in shape-based auto router and 3D Preview & Export, Component Editor, and Pattern Editor.

iv. **SinaProg:** SinaProg is a Hex downloader application with AVR Dude and Fuse Bit Calculator. This is used to download code/program and to set fuse bits of all AVR based microcontrollers.

v. **Raspbian Operating System:** Raspbian operating system is the free and open source operating system which Debian based and optimized for Raspberry Pi. It provides the basic set of programs and utilities for operating Raspberry Pi. It comes with around 35,000 packages which are pre-compiled software's that are bundled in a nice format for hustle free installation on Raspberry Pi. It has good community of developers which runs the discussion forms and provides solutions to many relevant problems. However, Raspbian OS is still under consistent development with a main focus on improving the performance and the stability of as many Debian packages as possible [10].

5. EXPERIMENTATION AND RESULTS

Figure 5: experimental setup for Node1

As shown in figure 5, experimental setup for node1 consists of mobile robot with central server, GPS module, camera and other sensors. All sensors are successfully interfaced with microcontroller and the microcontroller is interfaced with the raspberry pi.GPS and camera are also connected to raspberry pi. Test results shows that the robot can be controlled remotely using wireless transmission of PC commands to R-Pi.R-Pi forwards the commands to microcontroller and microcontroller gives signals to motor driver in order to drive the Robot.GPS module provides the co-ordinates for the location of the robot.5

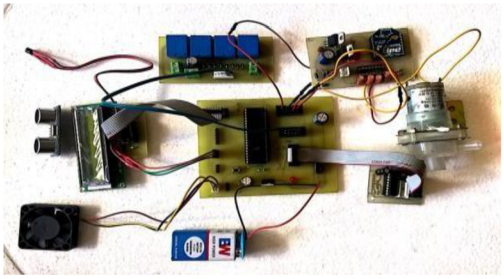

Figure 6: experimental setup for Node2

As shown in above figure, node2 consists of motion detector, temperature sensor, humidity senor, cooling fan, water pump, etc. connected to the microcontroller board. The sensors gives input to the controller and according to that microcontroller controls the devices in auto mode and also sends the value of sensors to R-Pi and R-Pi forwards it to user's smart device using internet. Test results shows that when temperature level increases above preset threshold level then cooling fan is started automatically in auto mode. The water pump also gets turned ON if moisture level goes below fixed threshold value. In manual mode, microcontroller receives the controlling signals from R-Pi through ZigBee and accordingly takes the control action.

Figure 7: experimental setup for Node3

As shown in above figure, node3 consists of a moisture sensor connected to HT12E. Moisture sensor transmits the data using HT12E Encoder IC and a RF transmitter to the Node2 where it is processed by microcontroller and accordingly water pump is switched ON/OFF.

Smart Agro Mobile Application

The farmers are the end users of this application. This application will provide full wireless connectivity to the farmers for their farm. The processed data from the cloud will be accessed by the farmers using this mobile application. The farmers will get a graphical representation of data as well for better understanding of the parameters. With the help of this data analysis the farmers will be aware of the climatic conditions of the farm and accordingly will control the devices such as light and motor pump. Each farmer will have its own account through which he can login using a unique username and password. New users can register using their email ID and create a new account. The farmers will get the direct readings from the sensors for the node they have selected. Based on this they will also get an alert for which device should be switched on or off [10].

The farmers can thus check for the readings and wirelessly control the devices for the field. Apart from this the application also provides other beneficial services for the farmers as follows:

1. **Weather forecast:** The application will provide time to time weather forecast for the farmers including the minimum and maximum temperature for the period, the humidity, wind pressure and chances for rainfall. This will well prepare the farmers for the climatic conditions and accordingly the crop parameters will be controlled.
2. **Agro calendar:** The application provides the facility for the farmers to store in the events in the agro calendar. Events such as the date of seed sowing, harvesting, spraying pesticides, etc can be stored by the farmers. The agro calendar in change will generate notifications for the maturity of the events to occur.
3. **Notifications:** The farmers will get app notifications for new updates regarding the weather changes. Also, notifications from the agro calendar regarding date of harvest, pesticides and fertilizers will be generated.
4. **Agro News:** The application will also provide the latest news of agriculture and farming which again is to keep the farmers updated regarding the news.
5. **Multilingual:** This application will be multilingual so that the local farmers can get total benefits of the services provided.

6. CONCLUSION

In this paper we have made an attempt to give proper information to the manual work of the farmers and make them a smart farmer. We have implemented a proposed system that will collect data from multiple nodes and using this existing sensor data the farmers will be able to control the operations on the agricultural field wirelessly and remotely anytime through mobile Applications. The qualitative sensors and microcontrollers of all three Nodes are successfully interfaced with raspberry pi and wireless communication is achieved between multiple Nodes. Throughout all observations and experimental tests proves that project is a complete solution to field activities,

irrigation problems, and storage problems using remote controlled robot, smart irrigation system and a smart warehouse management system respectively. Implementation of such a system in the field can definitely help to improve the yield of the crops and overall production.

This proposed system will be a quality service provided to the farmers for digitalizing agriculture with smart efforts. In near Future possible work on this proposed system may include centralizing the data and providing services for each crop individually through Artificial Intelligence.

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