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Design and Implementation of Remote Sensing Robotic Platform for Precision Agriculture

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Abstract: ***Smart agriculture plays a vital role in counties economy and development. Automation in the field of agriculture has led to the usage of autonomous robots for many field applications. In this scenario, remote monitoring of various field parameters are highly imperative for increased productivity. In order to demonstrate the usage of robots in agriculture, environmental monitoring robot was designed in this work. The first part was designed to collect soil moisture and temperature data from farm land and secondly to aggregate the data from the sensors. Finally, the data from the sensors will stored in the cloud for further processing and decision making for controlling actuator part. Overall system can increase the crop productivity and reduce the wastage of resources.***

Keyword: Soil moisture; Smart agriculture; Agricultural robot;

I. INTRODUCTION

In the era of Internet of Things (IoT) everything has been connected and evolved as smart applications. Today, it has reached almost all the domains such as healthcare, agriculture, transportation, consumer livelihood and so on. In this context, world population is expected to grow exponentially and has created the need for increased production to accommodate the growing requirements [1-3]. Smart agriculture is quickly becoming popular and has attracted huge investors. Thus, agricultural industry has started to adapt new and advanced technologies such as remote sensing using various techniques include IoT based agriculture [1], cloud based environmental monitoring [4] and autonomous robotic based monitoring and management system [5]. Among them, robotic based environmental monitoring and field management system has been widely used for modern farming [5-7].The field robot continuously monitoring the environmental changes and also used for implementing advanced technologies in farming. Precision agriculture can also be used with the aid of robotics in agriculture starting from weed picking, harvesting, segregation of crops, packaging and so on [6-8].

In this context, effective management of the available resources are highly imperative for increased production and to reduce wastage in farming. Particularly, in developing countries most of the farmers are minimum stockholders with an average of five acres for each person. These small farmers on following conventional methods of farming could lead to wastage in many aspects such as excessive use of fertilizers, pesticides and water ultimately leads to less crop yield, low quality or crop losses [8-11]. Conventional soil testing will be expensive and time consuming for adapting right crop for particular field area.

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Precise soil moisture, temperature, type is required for determining type of crop and expected yield. Soil moisture monitoring is required for adapting effective irrigation control [9]. Different types of crops requires various strategies for irrigation to maintain optimum soil moisture. Agricultural robot with soil moisture sensor can provide solution for maintain proper irrigation methods. In addition to that, it can provide soil moisture as well as temperature from dynamic regions of a farm. This can help in many aspects of farming such as to monitor the moisture according to daylight at different times, filling water to the paddy fields at right time and so on [9-10]. In this work, an agricultural environmental monitoring robot has been developed for monitoring the temperature, moisture, VoC presence in the fields [11-15]. It can collect the field data from different parts of the farm and send to the central server. The central server further send to multi-function farmland mobile app to real time monitoring of farm land.

II.MATERIALS AND METHODS

Figure shows the functional block diagram of proposed system. The proposed system consists of three components include field inspection robot equipped with IoT component, remote server equipped with data storage capacity and mobile application to monitor and control farm field appliance according to environment report. The detail description of each unit is described as follows.

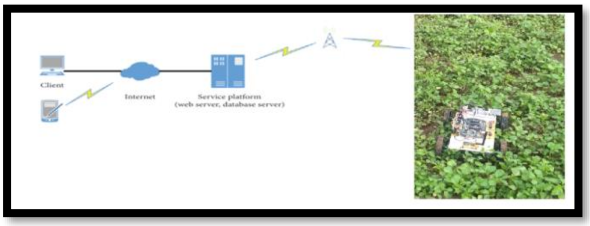

Figure 1: Block diagram

A. FIELD INSPECTION ROBOT

The figure shows our field inspection robot. It consists of Arduino Uno based control unit, sensing unit and IoT communication unit. The detail description each unit is described as follows.

Figure 2: Field Inspection Robot

B. ARDUINO UNO BASED CONTROL UNIT

Figure 3 shows the schematic representation of central control unit. It is designed using Arduino mega based on ATmega 2560 microcontroller. It is power with Arduino Mega 2560 is based on ATmega2560. It Consists of 54 digital pins, 16 analog inputs, 4 UART (Universal Asynchronous Receiver and Transmitter). The central control unit generates required control signal to both sensing unit and IoT communication unit. The on chip analog to digital convertor receive the analog signal from sensor and convert into corresponding digital value with 10-bit precision. The converted digital data are sends to remote data analysis unit through IoT communication interface.

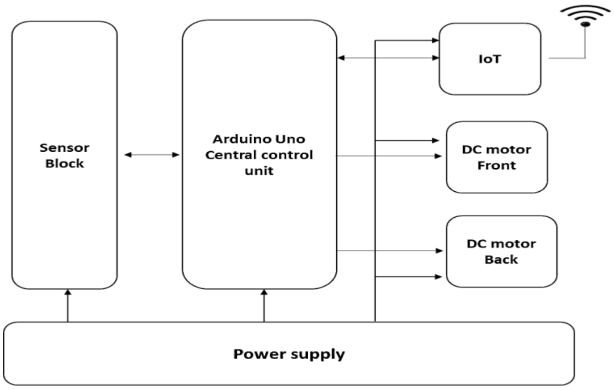

Figure 3: Central Control Unit

III. SENSING UNIT

Sensing unit gathers the environmental parameters from field. It collects four different parameters like temperature, humidity, soil moisture, light intensity and volatile organic compounds (VOC) in air. The sensing unit comprise of four sensors namely digital humidity and temperature sensor, soil moisture sensor, light intensity sensor and MQ 137 sensor.

A. Temperature and humidity sensor

Temperature and humidity play a vital role in growth of any crop. Humidity and moisture are directly correlated, where soil moisture is another important factor in determining the plant growth. Over moisture can lead to pest attacks while lack moisture will affect the plant growth. Optimum moisture should be maintained to accelerate the growth and increase the productivity. In this design we use DHT11 sensor module for measuring the temperature & humidity. It consists of capacitive humidity sensor, NTC temperature sensor and 8-bit microcontroller for generate the digital output. The module generates the temperature & humidity every two seconds. It is capable of measuring up to 125 125 degrees Celsius with +-0.5 degrees accuracy.

B. Soil Moisture Sensor

Soil moisture is another important factor for any agricultural crop. Soil moisture is directly influenced by environmental temperature, which affects the texture of soil. Very high or vey low soil moisture will harm the crops resulting poor yielding. Volumetric water content is measured using soil moisture sensor with an accuracy rate of ±4%. Dielectric permittivity is measured as a function of water level using capacitance principle. Through this sensor, the robot measures the loss of moisture over time due to evaporation and plant uptake.

C. Light Intensity Sensor

Light is the key component in plant growth and photosynthesis. In this work, GY -30 bh1750 digital light intensity sensor is used to measure the intensity of the light from sun falling on the field. The sensor can able to measure the light intensity range from 0 to 65,535 Lx.

D. VOC Sensor

VOC can be used as indicators of pant growth and field conditions. They are released by plants as a by-product of plant physiological process. Generally, ammonia play vital role in plant growth. Here, ammonia volatilisation from agricultural land is a loss of nitrogen due to plant growth. Similarly, carbon dioxide (Co_2) can be used as the indicator of photosynthesis rate in plants. In this work, TGS 826 is used for measuring ammonia concentration. Increase or decrease in Co_2 may affect the plant growth and by monitoring Co_2 plant health and growth can be critically monitored.

E. Wireless data communication unit

In this system design SIM2000C CDMA 800 MHz transmission module is used for data communication in the network. It is a low power consuming device with a downlink speed of 153 kbps. The command from Arduino serial port is fed into communication port and socket-based communication module is used. TCP/IP protocol is used for communication. The data from the network is transmitted and stored in the local machine in prescribed data format. Data will be displayed and transmitted upon query from user and process data accordingly.

IV.REMOTE DATA COLLECTION UNIT

Remote data collection unit comprise of data storage and mobile data sharing unit. The detail description of each module is describing below.

A. Cloud server

The remote data storage unit receives the data from sensing unit and store it into cloud server. Web server application has been designed to gets agriculture information from sensing unit. In this work, Apache and MySQL database run on Virtual Machine (VM) using Ubuntu 14.04. Vsphere control panel is used in order to increase resource optimisation of VM with reduced downtime and data complexity. If the developed system requires more sophisticated system in future, it can be easily migrated to any cloud based system like Amazon Web Service (AWS).

V.EXPERIMENT RESULTS

This section describes the experiment results of the proposed scheme. The experiment was performed in real world environment with our robot. Initially, the robot is trailed in paddy field and collected the environmental parameter include temperature, humidity, soil moisture, light intensity and VOC gases include ammonia and Co2. In data collection process, the robot is operated in tele-operated mode. The data collection was performed for 30 days with different time period and different paddy filed condition include fully dry, wet condition and paddy field is filled with enough water. In the experimental study, the system was continuously worked for 48 hours and the measured parameters were recorded once every 10 min using data logger software as shown in figure 4.

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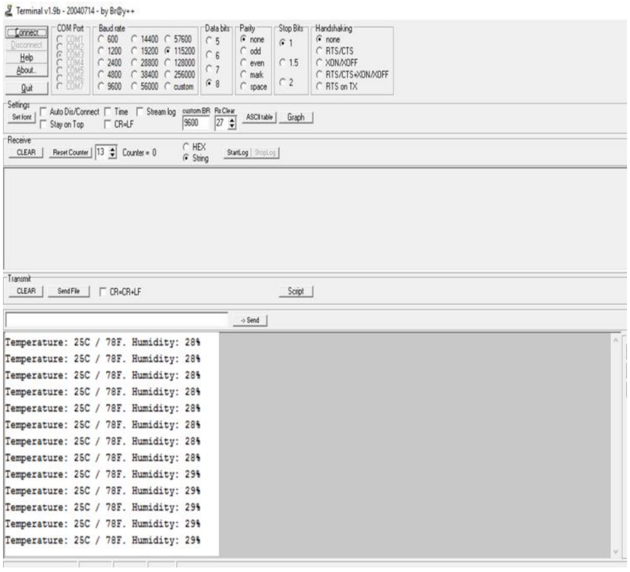
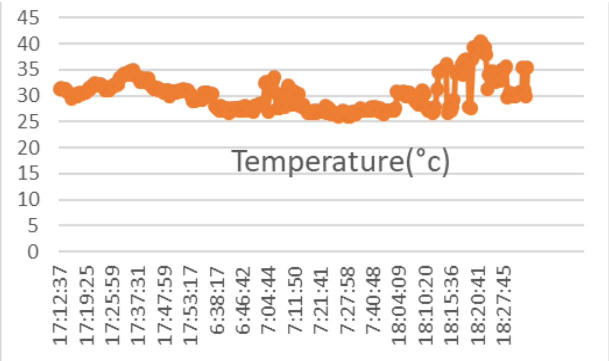


Figure 4: Data logger software

The developed system will show 100 results for temperature, humidity, light intensity and soil moisture.



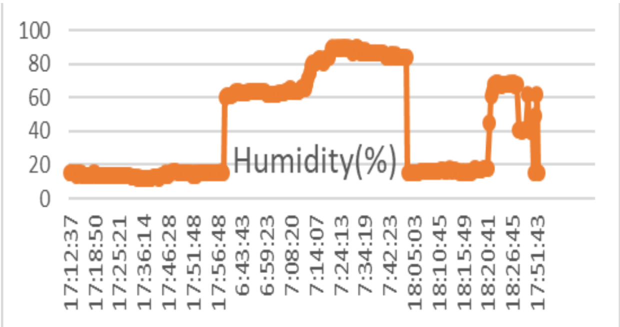
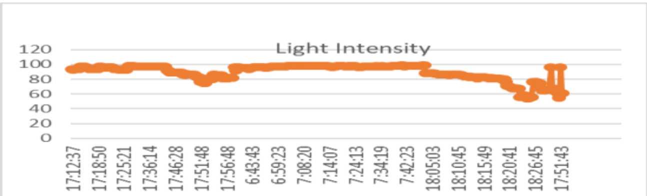


Figure 5: Air results collect from DHT11 sensor



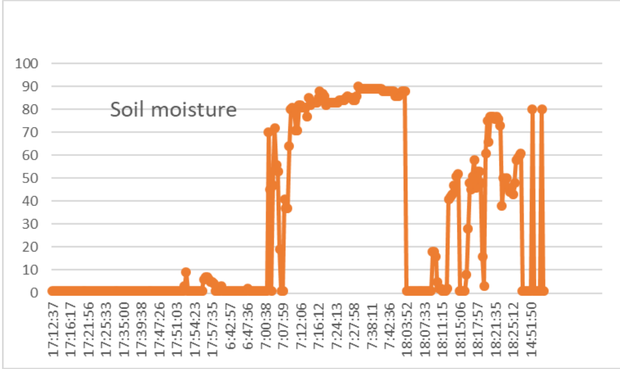


Figure 6: Light Intensity Sensor & Soil Moisture sensor results

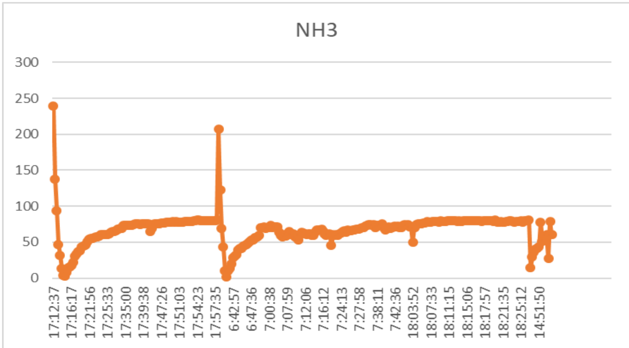


Figure 7: Ammonia sensor results

Figure (5-7) shows the random continuous 300 experimental results of temperature, humidity, light intensity, soil moisture and ammonia sensor results. In this analysis, sensing module predict the temperature, humidity and light intensity with absolute error is +2.1 ◦C, the average relative error is 2.84%, +9% RH and +10.30 Lx respectively.

VI.MOBILE APPLICATION

Mobile application provides easy to visualise user interface and shows parameters such as greenhouse gas and other farmland information. The mobile app operations are connecting to the network services and open the application. Click connect to farmland server. Once the application successfully connected to server them data from the server can be viewed using mobile application.

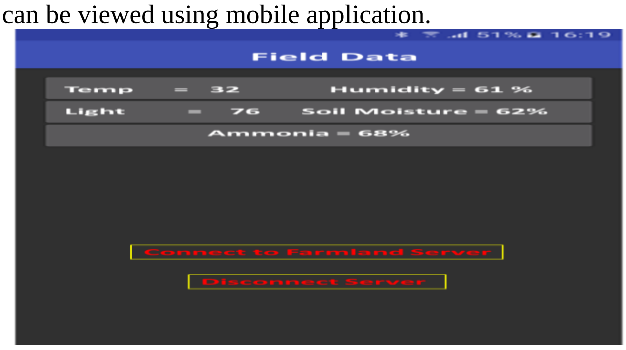


Figure 8: Mobile application for real-time farmland monitoring

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VII.CONCLUSION

In this work, we proposed a remote sensing robotic architecture for precision agricultural applications. Various environmental sensor has been utilized to measure multi-parameter information like temperature, humidity, light intensity and VOC in a small agricultural environment. The sensing device measure the environmental parameter with less absolute error. Further, the developed agricultural robot works for farmland data collection and multiple parameter measurement. The experimental results proved that the proposed scheme is more suitable for real time precision agricultural applications.

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