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IoT Based Crop Field Monitoring and Irrigation Automation System

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Abstract
Internet of Things (IoT) is a shared network of objects or things which can interact with each other provided there is internet connection. IoT can play an important role in the agricultural industry which can feed over an estimated 9.5 billion people on the surface of this earth by 2050. IoT based crop-field monitoring and automated irrigation system which also can be called Smart farming system can help to reduce wastage, by enabling the effective usage of fertilizer and soil water thereby increasing crop yield. In this work, a system is built to monitor crop-field using sensors (Temperature, Humidity and Soil moisture) and to automate the irrigation system. The data from sensors are sent to the Thingspeak API database using wireless transmission. The data can be visualized on the designed Web page where the readings from the sensors can be viewed. The data are encoded in JavaScript Object Notation (JSON) format. The irrigation is automated in that irrigation is only enabled when the soil moisture of the field falls below the threshold for optimal crop growth.
The notifications are sent periodically to the web page dashboard as well as the mobile app developed for farmers. The farmer can monitor the field conditions anywhere, anytime.

Keywords: *IoT, Sensors, Automated Irrigation, Systems Integration, Crop yield.*

1. Introduction

Agriculture is as old as man himself. Agriculture has been the most important practice from very beginning of the human evolution. It has seen many recapitulations of improvement in technology with time. In Nigeria, a developing nation, tremendous effort is focus on improving agricultural productivity. Though about 70% of the populations are farmers, the country still depends heavily on the importation of food items. A major reason for this is that agriculture in Africa's most populous nation does not embrace technology. There exist a large valley between the many available research institutions and the local farmers. Environmental parameters such as soil moisture content, temperature, humidity, pH, solar radiation and many other factors, plays very important roles in overall development of the plant [1]. Farmers need agricultural information and pertinent knowledge to make knowledgeable decisions and to satisfy informational needs. The unavailability of these information with regards to water has reduced the average Nigerian farmer to a seasonal farmer that can only function with the cycle of the monsoon rainfall. Crops like maize, sorghum and millet are only cultivated at certain time of the year In agricultural domain through the development of a knowledge management system, enquiries of farmers with regards to crop behavior and the environment, can be answered with the help of multimedia which can be made easily accessible. The application of Information and Communication Technology (ICT) has provided the opportunities for widening and promoting agriculture on several aspects and domains in developing countries. Technology has crossed hurdles by using wireless technology, networking, and mobile connectivity to overcome the utilization of energy, power and cost consuming equipment which are very difficult to come by in Nigeria, but are very helpful in agricultural development. The development of ICT in various domains has driven substantial interest in raising investments by private sectors and in the development of many farming initiatives such as in rice and tomatoes farming [2].
IoT has the capability to transform the world we live in, by creating more efficient industries, connected cars, and smarter cities in the not too distant future. However, the application of technology like IoT in agriculture could

have the greatest impact especially in the developing world where there is paucity of infrastructure such as electricity and wired transmission lines. The availability of solar technology and wireless transmission systems and the internet can be embraced to overcome these deficiencies, especially through the IoT system. The global population is set to touch 9.5 billion by 2050 with a greater proportion of this growth happening in the developing countries of which Nigeria is one. So to feed this much population, the farming system must embrace IoT. Against the challenges such as extreme weather conditions and rising climate change, and environmental impact resulting from intensive farming practices, the demand for more food has to be met. Smart farming based on IoT technologies will enable growers and farmers to reduce waste and enhance productivity ranging from the quantity of fertilizer utilized to the number of journeys the farm vehicles have to make [3]. Smart farming is a capital intensive and hi-tech system of growing food cleanly and sustainably for the masses. It involves the application of modern ICT practices and techniques into farming.

In IoT based smart farming, a system is built for monitoring the crop field with the help of sensors. This affords the farmers the capability to monitor the field conditions from anywhere. IoT- based smart farming is highly efficient when compared with the conventional approach. In agriculture, irrigation is the important factor as the monsoon rainfalls are unpredictable and uncertain. Agriculture in the face of water scarcity has been a big challenge. There exists a demand for colossal technical knowledge to make irrigation systems more efficient [4]. Irrigation and agriculture are intricately related as the former and the latter go hand in hand. The reason for this bond is because water is very essential and vital for the survival of any form of life. Irrigation is the application of controlled amounts of water to plants at needed interval in order to grow crops. Irrigation is soil moisture dependent because soil moisture is recognized as one of the main drivers for plant bionetwork. Soil moisture content is a prerequisite for crop growth, and excessive soil moisture content may bring about rot to the roots of crops, take away a lot of fertilizer which can cause water pollution, stop gaseous exchange between soil and the atmosphere which reduces root respiration and root growth [5]. Water is critical for seed germination and uptake of nutrients by the plant and therefore, optimum level of moisture must be ensured for healthy growth of the root and overall development of the crop [5]. The practice of irrigation has always been an ancient practice which has evolved through different stages. For example, our forefathers watered their farms with the aid of buckets and watering cans while flood irrigation and sprinkler irrigation are part of the types of irrigation that are still being practiced today. These systems have been hit with several setbacks such as leaching off of soil nutrients, erosion (mainly due to flood irrigation), wastage of volumes of water, and many other deleterious effects on the farm. Automated irrigation systems can be very economical in this regard as it helps to conserve water. However, the savings from automatic irrigation systems can go beyond that. Manual irrigation targets plant roots with no significant degree of precision. In disparity, automated irrigation systems can be programmed to discharge more precise amounts of water in a targeted area, which promotes water conservation [6].

The goal of technology is to make the lives of human beings easier and simpler as long as the sun rises. It therefore endeavor to extend the chain of electronic life to the famers and provide a means of reducing the cost incurred during manual means of monitoring and irrigation, save time and energy, cater for the ever increasing competition of water with urban domains in developing countries. Technology has crossed hurdles by using wireless technology, networking, mobile, and so on, to overcome the utilization of energy, power and cost consuming equipment. The automatic functions are activated by feedback from field units and corrections in the flow parameters by control of devices in the irrigation system until the desired performance level is attained [7, 8]. This system is therefore designed to monitor crop-field using sensors (soil moisture, temperature, and humidity), automate the irrigation system and also provide accurate weather condition analysis. The data from sensors are sent to web server database using wireless transmission. The irrigation is automated since water is supplied to the crops if the moisture and temperature on the field falls below the brink (threshold) as determined by the water need of the crop. Notifications are sent to farmer's mobile app periodically to acquaint him with happenings on his farm. The farmers are therefore able to monitor the field conditions anywhere, anytime..

2. System Design and Integration

Monitoring of temperature, humidity and soil moisture without being present at the farm location helps us to get a better outcome. This is because the sensors work during the entire life cycle of the crops and is present in-situ. Here, the main purpose is to design a system that will observe, control and monitor the crop-field environment and based on the information from the sensors (i.e. temperature, relative humidity and soil moisture) trigger the watering of the farm, thus making the administrator (farmer) to manage the data in real time (Figure 1). Here, the central node which is a Thingspeak API is responsible for passing information to management node via computer or mobile phone. IoT based crop-field monitoring and irrigation automation is designed to monitor various parameters that are necessary for plant development. The data from the field are gotten through the network of wireless sensors and transmitted through WI-FI. The data is converted to human readable format and presented through the data presentation. These data are analyzed and shown to users through web design and development system and mobile app. DHT11 temperature and humidity sensor, soil moisture sensor were integrated with the MCU (Microcontroller) of the ESP8266 NODE MCU to collect temperature, humidity and soil moisture readings from the farm field to be relayed to a remote user over the internet. These sensor readings are sent back into the control system to enable automated control. These readings are displayed on the LCD screen for the farmer to know.

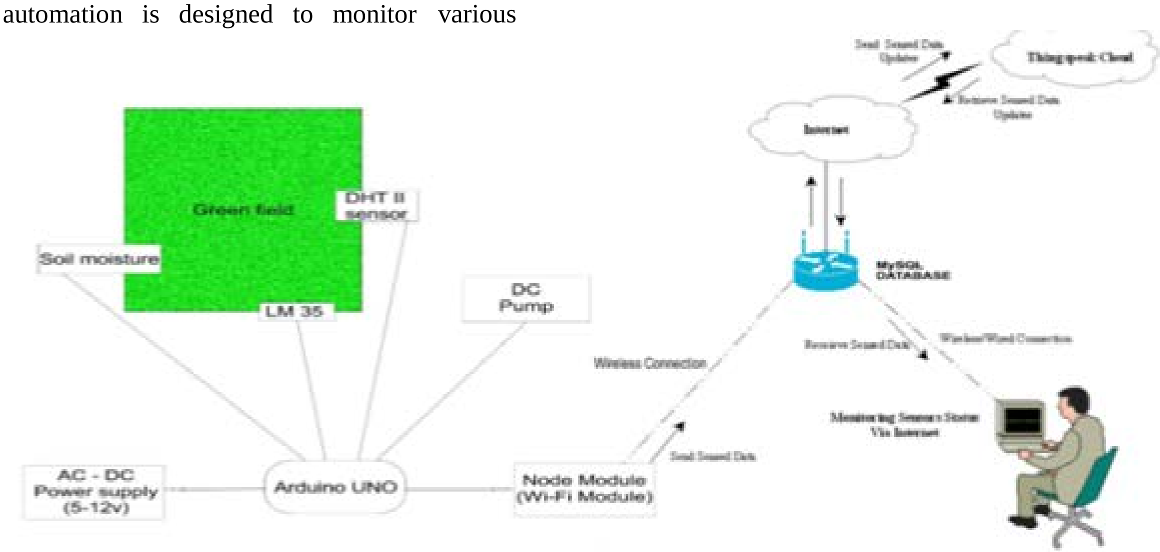

Fig 1. Overview of system design

2.1 Sensor data acquisition design

DHT11 temperature and humidity sensor, soil moisture sensor, YL 69 were integrated with the MCU(Microcontroller) of the ESP8266 NODE MCU (Figure 2) to collect temperature, humidity and soil moisture readings from the farm field to be relayed to a remote user over the internet. These sensor readings are sent back into the control system to enable automated control. These readings are being displayed on the LCD screen.

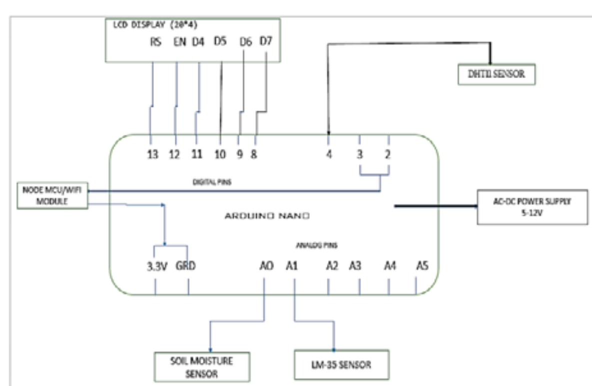

Fig. 2 Sensor data acquisition design

The data acquired from sensors are transmitted to the web server using wireless transmission. Node MCU ESP8266

WI-FI module is used for wireless transmission between the field and the web server. The data received from the field are wirelessly transmitted using WI-FI module of the Node MCU ESP8266 and then saved in web server "Thingspeak" database using internet connection at the receiver end. Periodically the data are received and stored in database. The data processing is the task of checking the various sensors data received from the field with the already fixed threshold values. The threshold values vary according to the crops planted. This is because different crops need different amounts of water. Similarly, the temperature and humidity varies for different crops. The sensor values also vary according to the climatic conditions. The soil moisture will be different in summer and winter seasons. The temperature and humidity also varies in summer, winter and rainy season. The threshold value is fixed after considering all these environmental and climatic conditions. The motor will be switched on automatically if the soil moisture value falls below the threshold and vice versa. The farmer can even switch on the motor from mobile using mobile application. Internet of things receiver was designed using NODEMCU ESP8266 Express Wi-Fi running a proprietary algorithm for data communication using HTTP. The Wi-Fi module communicates with the web design and development system rule engine using hypertext transfer protocol mode for the communication. NODEMCU ESP8266 Wi-Fi module is a self-contained system on chip (SOC) with integrated TCP/IP protocol stack that can give any microcontroller access to Wi-Fi network. Development of web server and web dashboard is an essential part of the project for processing of field data received to provide meaningful insight and visualize the data for public usage. Web server was configured using Thingspeak, open source IoT cloud platform from Mathworks with inbuilt functionalities to run MATLAB code, the data was analyzed using custom algorithm written in python, JavaScript and MATLAB programming languages and web dashboard was developed and hosted for easy accessibility to the visualized data using graphs and meter gauges. The mobile application was developed in android. The mobile application helps to monitor and control the field from anywhere. The mobile application uses PHP script to fetch data from the Thingspeak API database. The android fetches the data and encode it in JSON (JavaScript Object Notation) format to be displayed in android device. The user interface for the application was designed in a way that enables both the monitoring and control of field from the device.

2.2 Automation of Irrigation System

Irrigation system is automated once the control is received from the web application or mobile application. The relay was used to pass control from web application to the electrical switches using the Node MCU. A relay is an electrically operated switch. The relay used here is Solid State Relay (SSR). If an external voltage is applied across the ends the relay switches on or off the circuit. The process flow for the irrigation automation is shown in Figure 3.

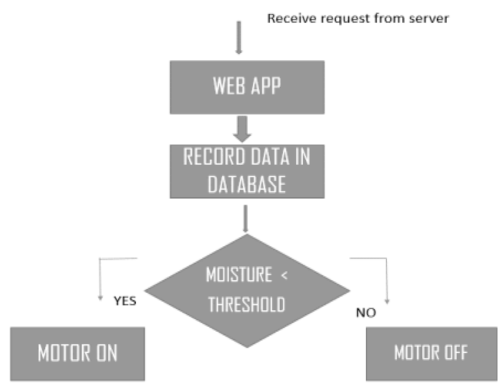

Fig. 3 Process flow for irrigation

2.3 Software Implementation

The Arduino integrated development environment software (IDE) was used which helps to code the Arm Processor of the Node MCU to interface the sensors and other type of components and perform the operation on both local and global domain with the help of library functions. Thingspeak account was also created through Mathworks account creation where the log in username and passkey for connecting to the Thingspeak API for storage, processing and visualization of the sensor data using the MATLAB was done. In Thingspeak, channel ID, READ API KEY (2DD8XG6ZPNL4DHZO) and the WRITE API KEY (N46QM36MDLSOUEXM) were given. Under the channel, four forms were created which corresponds to the measured parameters from the field and water pump control. Figure 4 shows the flow diagram describing the sequence of events during the software implementation phase of this work.

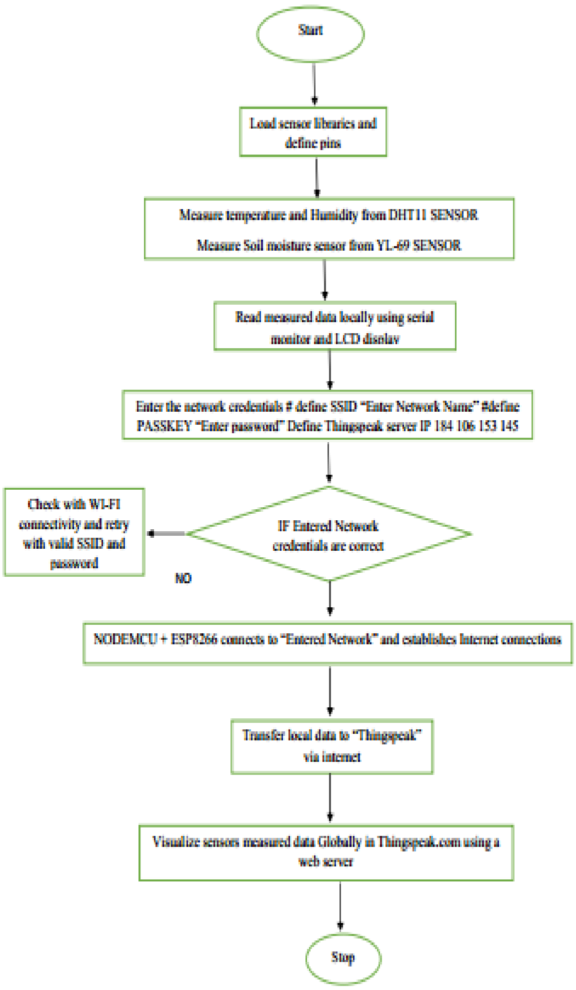

Fig. 4 Software implementation flowchart

3. Results and Discussions

Temperature, humidity and soil moisture sensors are connected to the ARM processor of the Node MCU via a breadboard. These sensors take values from the environment and send it to the web server via internet for further processing. The full circuit integration showing connections of all the components for the monitoring and irrigation automation is shown in Figure 5.

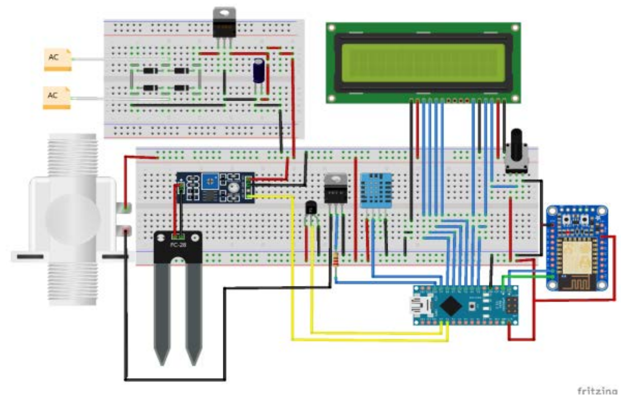

Fig.5 Integration of the full circuit

Data aggregated are automatically sorted and converted to excel sheet with Thingspeak data export. Data aggregated from the prototype satellites were visualized using Mathworks Thingspeak in real time. Web dashboard was developed for public and instant access to the data visualization. The web dashboard contains visual elements that shows various parameters measured by the sensors, the on and off state of the satellite and the data transmission time.

Fig. 6 Data Visualization of temperature using DHT11

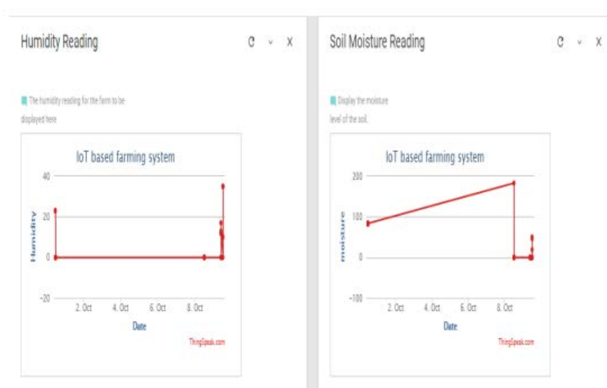

Fig.7 Data Visualization of relative humidity and soil m0isture using DHT11 and YL-69 sensors

With all the effects being considered, it can be concluded that adequate monitoring of these parameters is very paramount for optimum plant growth.

So as to make this a lesser task for the farmers, hence the design of this system which helps in monitoring all these factors and update the farmers on various happenings on the field and take necessary action when needed without any human intervention. The records of these readings can be viewed and visualized on the designed web page (Figure 6 and 7) and stored on the Thingspeak database for future reference and this can lead to precision agriculture

4. Conclusions

The system designed is capable of monitoring, reading and storing data using sensors and also generates some actions according to the data. Storing data in database allow for future research and also ensure that any abnormality in future can be studied and corrected helping to avoid future discomfort. Web and mobile application with a user friendly interface make the system easy to understand without requiring any special skills. The system takes decision of automating the irrigation when the need arises according to the instruction received, that is, when the soil moisture falls below the brink without any human intervention. This system is cost effective which makes it affordable for farmers. Due to non-availability of internet connection in some remote farms, this work can be reconfigure to incorporate GSM module for sending SMS to farmers.
The intelligence or decision making component of the system can also include some artificial intelligence modules so that the farmer's interaction with the system will be minimized this will lead to less human efforts for the monitoring.

References

[1] E. O. Ogunti, F. K. Akingbade, S. Adebayo and O. Oladimeji. “Decision Support System Using Mobile Applications in the Provision of Day to Day Information about Farm Status to Improve Crop Yield”, Periodicals of Engineering and Natural Sciences, Vol. 6, No. 2 , 2018, pp. 89 - 99.

[2] F. Awuor, K. Kimeli, K. Rabah and D. Ramblin, "ICT solution architecture for agriculture", in IEEE 1ST African Conference and Exhibition, 2013, pp. 524.

[3] J. Gutierrez,, J. F. Villa-Medina, A. Nieto-Garibay, and M. ÁngelPortaGándara, “Automated Irrigation System Using a Wireless Sensor Network and GPRS module”, in IEEE Transactions On Instrumentation And Measurement, 2014

[4] H. Gao, Z. Ouyang, S. Chen, and CSA Koppen, "Role of culturally protected forest in biodiversity conservation in Southeast China", Biodiversiry Conserv., Vol. 22, 2013. pp. 531-544.

[5] M. Rajkumar and H. Freitas. “Influence of metal resistant-plant growth promoting bacteria on the growth of *Ricinus communis* in soil contaminated with heavy metals”, Chemosphere, Vol. 62, 2008, pp 741 - 748

[6] J. Uddin, S. Muhammad, T. Reza, Q. Newaz and J. Kim. “Automated Irrigation System Using Solar Power”, in 7th International Conference on Electrical and Computer Engineering, 2012, pp 228-231

[7] M. Ibrahim, I. S. Tyabo, U. S. Mohammed, I. S. Umar, and A. Abdullahi. “Appropriateness and Reliability of Agricultural Information Sources among arable crop farmers in Karu and Kokona Local Government areas of Nassarawa State Nigeria”, Nigerian Journal of Agriculture, Food and Environment, Vol. 12, No. 3, 2016, pp 114 - 118

[8] A. A. Whitmore.. "The Internet of Things—A survey of topics And trends", *Information Systems Frontiers*, 2015, pp. 261

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