

Development of Smart Agricultural Monitoring and Irrigation System using IoT and Mobile Applications

Sittichai Choosumrong^{1*}, Rhutairat Hataitara¹ and Thitisak Pothong¹

¹ Department of Agriculture Natural Resources and Environment, Faculty of Natural Resources and Environment, Naresuan University, 99 Moo 9 Tha Pho, Muang, Phisanulok, Thailand 65000

*Corresponding author: sittichaic@nu.ac.th

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Abstract

Nowadays, identifying and quantifying significant spatial and temporal variability in agricultural field has been a crucial factor for improving agricultural production and management. With the development of modern sensors and sensing technology, field information collection in precision agriculture could be achieved by a multiplicity of technologies, including Wireless Network Sensors (WSNs), Remote Sensing (RS), Global Navigation Satellite System (GNSS), and Geographic Information System (GIS). Among them, for the low-cost and low-energy consumption sensor nodes deployment, the WNSs have been widely used in agriculture for automated irrigation management, fertilization, pesticide detection and control, as well as environmental monitoring and greenhouse controlling.

In this work, we have introduced a way to apply IoT Sensor technology to mobile applications for field data collection, monitoring and controlling for agriculture. To collect data, the WSNs system was designed and developed for remote real-time monitoring and collection of the parameters. The parameters used in this experiment are temperature, humidity, and soil moisture. The developed devices and applications allow users to save data directly to the database, reducing the time it takes to complete the task. The data will have the coordinates from mobile GPS, sensor data, and its will be displayed through the Web Map Application to display the data in real-time.

Keywords: WSNs, IoT, Mobile GIS, Spatial web service, Geo-processing

Introduction

Digital technology and the internet have been recently a part of our daily life. Internet of Things (IoT) is that things are all linked to the Internet. One of the famous digital technologies is wireless communicative devices. There have been research studies on Wireless Sensor Networks (WSNs) concerning water, soil, and air quality verifications (Pule et al, 2017; Ojha et al, 2015; Aroonjit, 2015; Karimi et al, 2018; Mokhtary, 2012) Those studies have some developments in the data logger, real-time monitoring, etc. However, most of those developed systems have been only for verification and data recording only. There are still not analyses and spatial results shown.

Therefore, this study presents the application of IoT and Sensor technologies integrating with mobile applications to record the field data, verify, and control the data for the agricultural section. WSNs system has been designed and developed to monitor environmental data and collect real-time parameters. The parameters in this experiment included temperature, relative humidity, and soil moisture. The tool and application have been developed to be able to record the data into the database directly which can reduce the work period. The data will include the coordinates of where they have been collected.

WSNs when used in any circumstances, the sensor node will collect and process their data. This tool is connected to smartphones through wireless technology (wireless internet). WSNs have been the new interesting computer technology for agro-industry, especially the expansion of Micro-Electro-Mechanical Systems (MEMS). This technology is useful for making a small and cheap sensor which leads to the development of a sensor system for agriculture using standard and cheap sensors with open hardware and open-source software.

Sensor Observation Service (SOS) is the standard web service interface used to request, filter, and retrieve observations and sensor system information. This is the intermediary between a client and an observation repository in real or near real-time sensor network. Since SOS provides accessibility to the required information, decision-makers can make the right decision in terms of critical situations. This study has developed the WebGIS Application which has been designed to show the data from field database in a map and graph format for users to access and follow up the sensor data (Choosumrong et al, 2016)

Thailand is an agricultural country including both major and minor agricultures. Those who do the minor agriculture usually face the problems of cost and labor as well as the weather changes that result in productivity directly and indirectly (Wan 2008). Due to the fact that collecting field data regarding agriculture needs a big data because of the area changes which is the key factor in doing modern agriculture, new technology and solutions have been considered for the best choice of collecting and processing data to improve the potential (Kaivosoja et al, 2014)

Despite many applications or sensor systems, e.g. WSNs for multipurpose agriculture including WSNs for environmental verification, and soil humidity will be applied to predict the plant's demand of water and the plant's health, some of the collected data are stored in data logger which is difficult to access and takes a long time. In addition, the tool is highly required to be accurate. In order to solve those issues, the researcher team has developed modern sensor technology to collect field data in agriculture more accurately. This technology can be applied by several tools such as WSNs, RS, GPS, and GIS.

The aim of this study is to develop a real-time weather monitoring and evaluation using sensor technology and deploy the system through Web Processing Service and to develop applications that can control sensor devices.

Conceptual Framework and Methodology

In this section, the research team will explain the sensor network for agricultural field data collection, emphasizing sensor technology about agriculture. The development of a sensor system to collect field data consists of 3 main parts as follows:

Wireless Sensor networks

WSNs are the sensor network using a battery. This network connects to each other through a wireless connection and works in the specific purpose. Data received from these sensors will connect to each other and work according to the written program to process and send the data to the user's smartphone. The set of field data collecting sensor consists of the followings:

Temperature & Humidity Sensor (DHT22) is the sensor for measuring temperature and relative humidity in the air which has been designed for accurate measurement. Its accuracy for humidity measurement is $\pm 2\%$ RH, temperature measurement is ± 0.2 degree Celsius. The sensor can measure relative humidity between 0–100% RH, and temperature between -40 to 80 degree Celsius.

Soil Moisture Sensor is applied to measure the soil moisture which can be connected to the microcontroller by using input analog to read the humidity sent from the module. The sensor works with PCB plate to measure the soil moisture and connects with WemosD1 R2 board.

WemosD1 R2 Micro Controller Board is developed as an open source board controller which reveals both hardware and software information. Its size and stands were designed to be similar to Arduino Uno board in order to be able to receive–transfer data through internet network i.e. Wi-Fi, 3G, and 4G. This board can be written via the Arduino IDE program.

Mobile Application

This is a part of adapted mobile program development such as mobile phones and tablets. The program responds to the consumer's demand and is easy to use. This study has developed an Android application to be able to show the data measured by the sensor and to transfer it into the database through Wi-Fi, 3G/4G networks.

Web Application

At the present, web applications have been very popular because of their effective response to the users' demands. Web applications work as a client/server which has been set up in the server of the user's device or the client device connected with the network. Users can work through a web browser immediately without downloading any other applications.

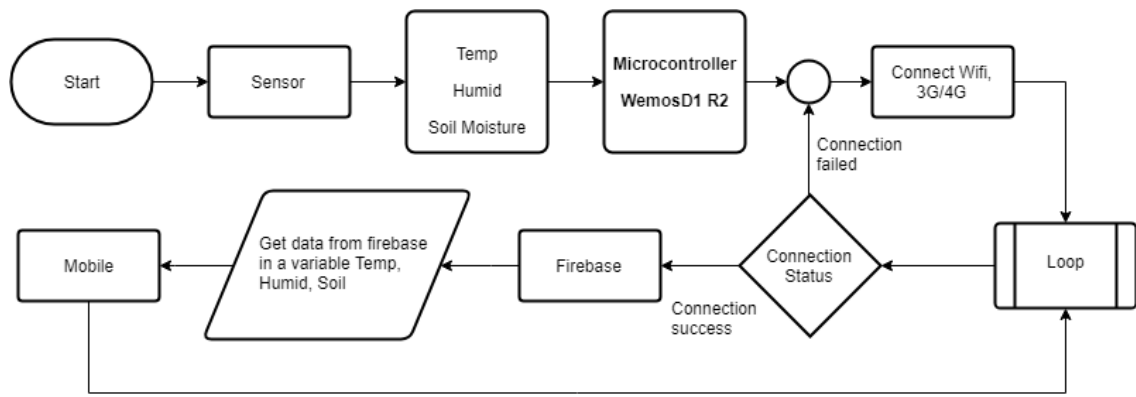


Figure 1. Diagram of WemosD1 R2 microcontroller board

The WemosD1 R2 operation began with the setting up of the sensor and connecting to Wi-Fi, 3G, or 4G network. When the connection is done, the controller board will collect the data measured by the sensor and store them in Temperature, humid, and soil parameters. Then, these values will be transferred to the Firebase and the mobile application will finally show the results.

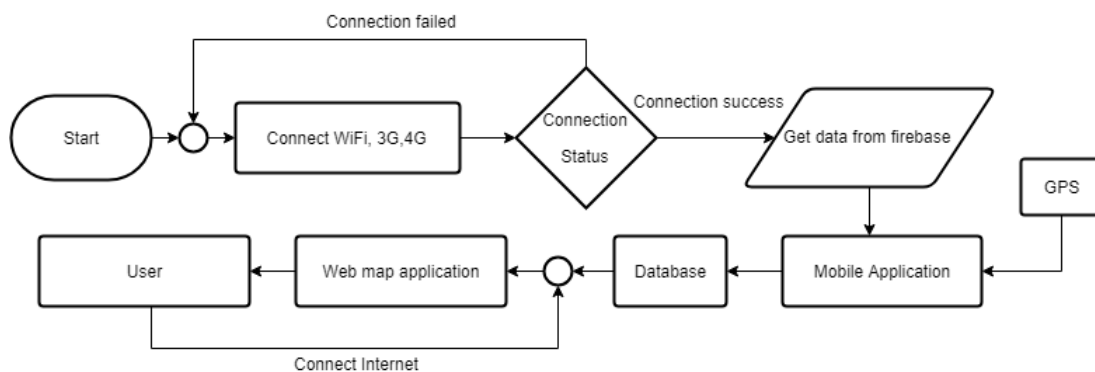


Figure 2. Mobile Application Diagram

The operation on a smartphone begins with connecting to an internet network. When it is completed, the application will take the data from Firebase to preview and show the real-time location data. Users can send the data with the location data from the sensor through the application to the database. The data will be later processed and shown through the web map.

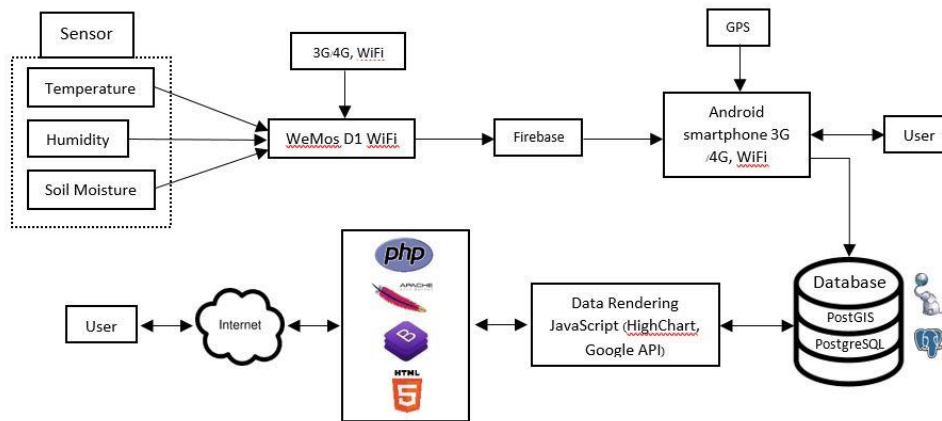


Figure 3. Design of sensor network

System Investigation Scenario

The examination of sensor operation for agricultural data collection and the application operation is divided into 2 phases: 1) sensor system to monitor the environment and collect field data through a wireless network; and 2) sensor system to track the environment and control the microcontroller and other devices through a wireless network.

Sensor system to monitor the environment and collect field data through a wireless network.

In the accuracy examination, the sensor results have been calibrated and compared for the soil moisture with HydroSense II which is a high accuracy sensor as shown in Figure 4. The cloud system has used Firebase service, while the connection with users has used a smartphone application. Users use a smartphone application to monitor the real-time data and send them to the database. The developed system has been examined for its real-time monitored data transfer to the database. The received data included the location of the data collection area. The data stored in the database will be shown on the website which has been developed to monitor and a map of the collected data. The correcting Soil Moisture (SM) data of this equipment after celebrate is $SM = SM - 40$. WSNs have proved that it is important to monitor real-time data.

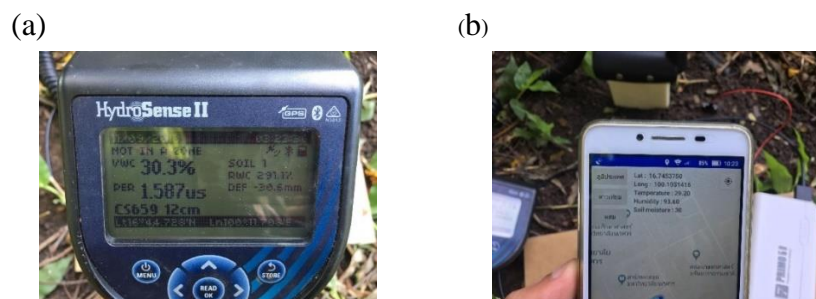


Figure 4. Shows the comparison of the values measured by the sensor with corrected values. (a) HydroSense II

(b) The collected data from Arduino sensor

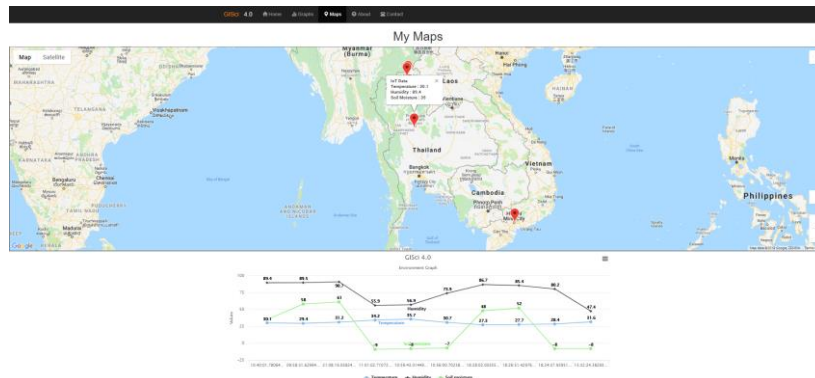


Figure 5. The web browser displays the environment information and the location map

Sensor system to track the environment and control the microcontroller and other devices through a wireless network.

This system is the development of the sensor system and the application for measuring the environment of an agricultural area. It also controls the on/off of electric devices such as water pumps, lights, etc. The examination has been a monitored in the real-time situation. The sensor could monitor and transfer the data to the application screen. Users can also turn on/off the electric devices through internet network.

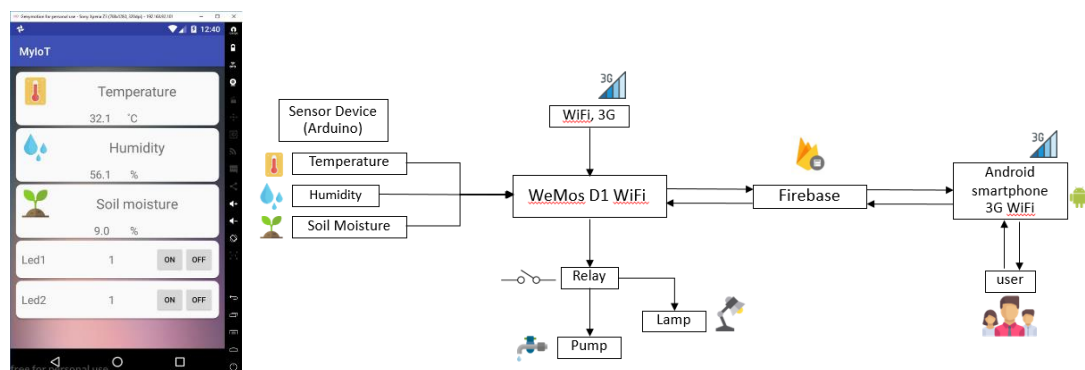


Figure 6. Smartphone application preview page for displaying environmental information and controlling electrical devices

Discussion and Conclusion

According to the sensor system development for environment monitoring, open source software has been employed in every process. The design of sensor system to be effective and able to apply to various kinds of work has made this study better than Aroonjit (2015); So-In et al. (2013) and Wan et al. (2008) whose studies have applied sensor system to the smart farm agriculture. The disadvantage of the previous studies shows that users cannot see the data through smartphones, nor can they control the electric devices. Therefore, the researcher has developed this system to solve that problem by integrating a sensor system to a website application in which its raw data could be processed and analyzed on the website.

As mentioned earlier, this application and sensor system, developed for farmers to be able to access the data and buy at a lower price rate, would help farmers to improve their productivity. The application can be integrated with any sensor system according to the farmer's desire. Moreover, this system is applicable to any version of smartphones.

According to the results, it can be concluded that the system to monitor the field environmental data through wireless connection could monitor the environmental data and transfer it to the smartphone application in real-time. Users can apply this system to collect the field data and send them to the database. The web browser can preview the collected field data and process in a real-time situation. The smartphone application for showing the environmental data and controlling electric devices can monitor real-time data and control the electric devices via the internet network.

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