

Development of an IoT Based Weather Station System for Monitoring Agricultural Products

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ABSTRACT

The main abstraction behind the Internet of Things (IoT) is the ability to join various electronic devices through a network and then recover the data from these devices (sensors). These devices can be distributed in any fashion, uploaded to any cloud service for analysis and process the obtained information. This study aims to develop an IoT based weather station system for monitoring agricultural products. The specific objectives are to design an automatic electronic station board, interface the station to an android device and test the system. In this study, the humidity, temperature, raindrop sensors and other power supply components were employed for the implementation of the system. Each sensor is attached to their respective microcontroller ports as input while ESP8266 processes the income analogue data into digital form and finally store the result into firebase. The connected sensors measure atmospheric condition in analogue form which is presented to microcontroller for execution. The recorded data are store in real time database (firebase) and transferred to Android mobile phone for displaying. The android application has been linked to the firebase for the purpose of fetching the data and output the result to be displayed on a mobile phone. The Android mobile phone display the final result through the mobile application for further analysis. The result was obtained at different hours and the output result was represented graphically. The obtained result showed that the developed weather station can be effectively used to monitor agricultural products.

1. INTRODUCTION

Weather station systems are electronic components that are sensitive and reliable for monitoring of farm products (Rao *et al.*, 2016). The main purpose of using weather station is controlling and monitoring as well as planning agricultural process. The system monitors the climatic condition and the changes that can be encountered. The design requirements of the systems are inexpensive especially the systems that periodically observes and supervises large area of agriculture environment (Laskar *et al.*, 2016; Karthik *et al.*, 2015). The affluence and the supremacy of IoT microcontroller have contributed immensely to the development of this study. Internet of Things (IoT) is an idea that makes humans and physical objects interact through the internet in a real-time process (Asghar *et al.*, 2015). IoT enables not only human-human

communication but also human-device communication as well as device-device communication (Pauzi and Hasan, 2020).

The sensors in the weather monitoring system are the miniaturized electronic devices used to measure the physical and environmental parameters (Yashaswi *et al.*, 2018; Neha *et al.*, 2018). Using these sensors, the system will produce fast and accurate result with less power consumption. The use of these sensors will also enhance the farm productivity, thereby yielding more food to the nation. The growing in technology has enable the electronic sensors capable of monitoring environmental parameters more favourably (Gangopadhyay and Mondal, 2016). In recent years, climate change has not been stable and consistent for productivity of agricultural products. This volatility in weather condition has affected farmers across the country (Iswanto and Brahmantya, 2020), disturbed their farming plans and schedules; and largely reduced their productivity which is one of the main reasons for food scarcity running currently on in the country. The proposed weather station system will predict the stability of weather to enhance the productivity of agricultural products. The importance of weather monitoring system exists in various aspect of farming process.

Several weather station systems have been developed with different methods and technologies. Saini *et al.* (2017) worked on design and implementation of weather monitoring system which employed Arduino microcontroller. This work developed a weather station for monitoring weather in transportation industry. R programming language was used to evaluate results and reveal outputs. A control unit was setup to operate other appliances like Air-Conditioner, heater, fans etc. The limitation of the study was that it does not make use of wireless data transfer using Wireless Fidelity (WiFi) and mobile device to display the acquired data from the sensors. Katyalr *et al.* (2016) developed wireless Arduino Based Weather Station. The work described a system with Arduino which function using a WiFi shield and different sensors like DHT11, BMP 185, Rain sensor, soil moisture sensor, etc. Think speak was adopted in order to use MATLAB to get knowledge from the information obtained from the readings on the server. The limitation of the study is that the rain sensor can only detect when the rain is falling but it cannot measure the volume of rainfall within a period of time and the output of the result is only simulated on MATLAB not in real time base.

Bulipe *et al.* (2016) explained in their study titled Internet of Things (IoT) based weather monitoring system, seeks to monitor the weather conditions at a particular place and make the information visible anywhere in the world. The author adopted the used of Sensors ZigBee, Radio frequency Identification (RFID) Tags, Mobile phone sensing, Wireless Sensor Network (WSN) Gateway and a Database. The result of the study revealed that the system was able to monitor weather conditions efficiently and effectively. The only limitation of this work is that if voltage is low, it will be difficult for RFID to detect signals which results to data reading failure. Singh *et al.* (2018) developed Arduino Based Weather Monitoring System. These systems form an automated weather monitoring system that uses sensors like light and rain for its implementation (Mahmood and Forat, 2017). Humidity and temperature of a room were sensed in the work. The limitation of the work lies in its inability to operate remotely and the collected data are not accessible.

In related work of Laskar *et al.* (2016), forecasting weather was considered. The weather system employed Arduino based Cube Satellite with an autonomous small cube that provides weather information without internet. The limitations of this system lie in its inability to communicate over long distance without powerful satellite network. Shubham *et al.* (2019) considered IoT based weather monitoring system using Raspberry Pi. The work proposed a system in which digital and analog sensors were used for environmental parameter measurement. The data from input sensors was then read by server and stores it in a csv and textual format.

Many studies have employed various techniques for weather station monitoring system but, in this study, the Firebase database was employed. This firebase is a cloud-hosted database which retains signal even

when there is no internet. The system fetches the command stored in the database as soon as the connection is restored. The data in the cloud service was deployed to android application which serve as user interface where all the information can be seen.

2. METHODOLOGY

2.1 System Design

In order to accomplish the purpose and arrive at expected result of this study, the implementation process follow the design framework as specified in the block diagram shown in Figure 1. The integrated system of weather station consists of ESP8266 and five sensors (rain gauge sensor, barometer sensor, humidity sensor, light intensity and temperature sensor, power section) as shown in Figure 2. The power section consists of four diodes (IN4007), capacitor and regulator (LM7805). The regulated 5V supplies power to the ESP8266 and the sensors. The written program executes, initialize the whole system and then operation commenced. Each sensor sends their analog reading to the microcontroller which convert the analog reading to digital. ESP8266 sends the digital reading over internet to firebase real time database to keep the readings. In this design, the IoT was configured as access point with its own Service Set Identifier (SSID) and Password which enable it to connect to any available configured mobile phone to send data to the database. The android mobile phone receives data from real time database through the firebase secret key address and Uniform Resource Locator (URL) linked with mobile application to entrench communication. The mobile app displays all the reading accordingly on android mobile phone for proper monitoring.

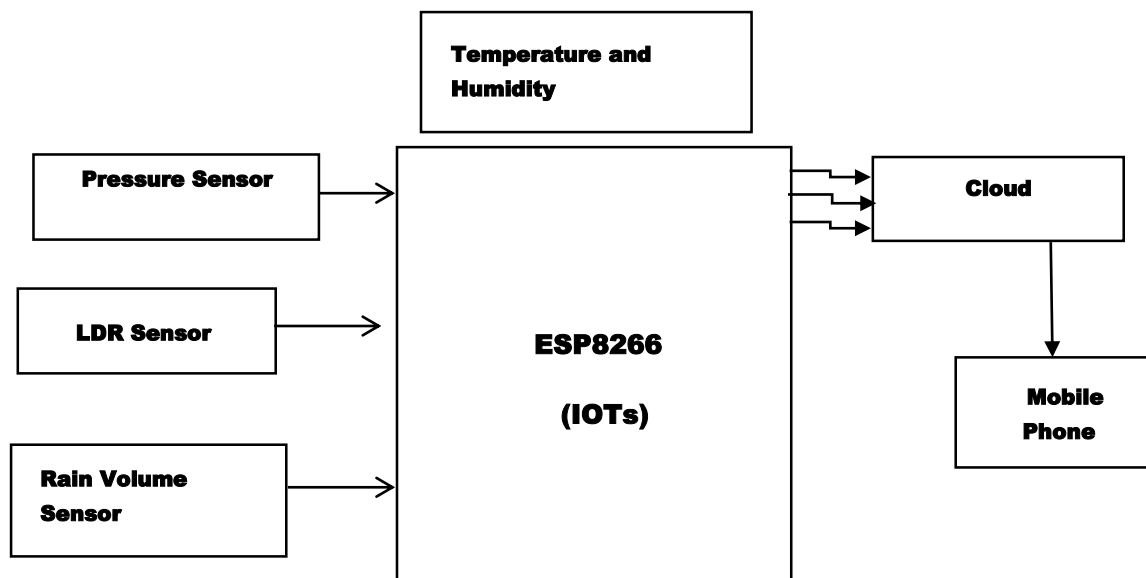


Figure 1: Block Diagram of the Proposed Weather Station System

2.2 Software Development

The software implementation also includes the development of the user interface for mobile application. The user interface for mobile application is a graphical interface where the system user interacts with the system. This development was done using MIT Inventor and Arduino C programming for IoT. C language as programming language was used to program IoTs microcontroller for receiving and sending the reading data to the cloud while MIT inventor was used to write mobile app to receive data from cloud. Firebase

database was employed as a cloud- hosted database to interface the hardware module and enable the mobile device to communicate with the Micro-controller effectively and efficiently.

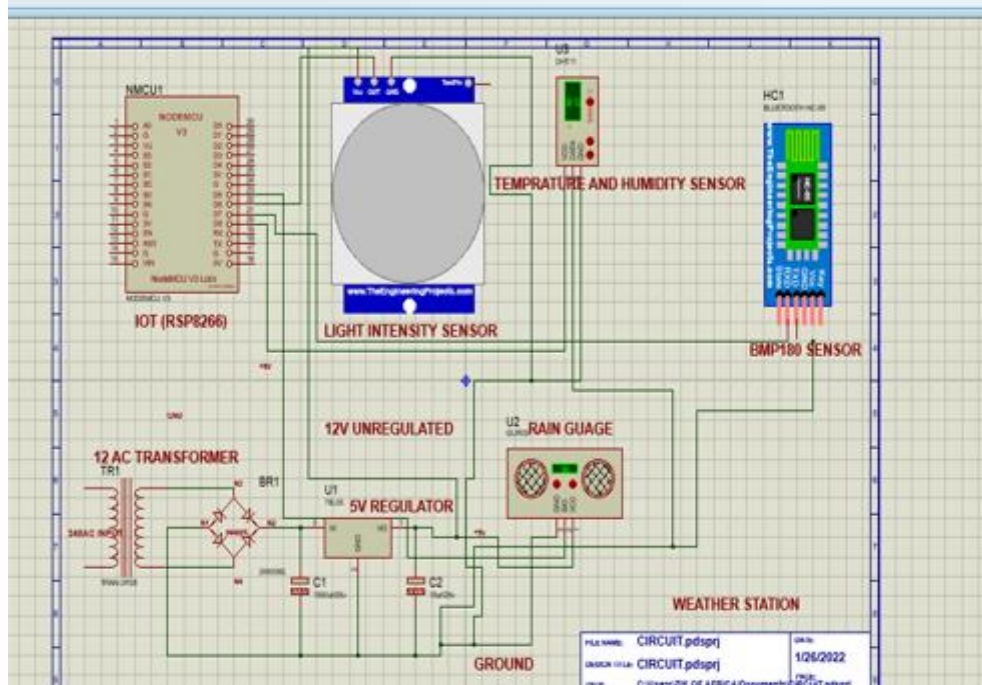


Figure 2: Circuit Diagram of Weather Station

2.3 Hardware Module

The system requires power source of +5 V and +12 V DC. One technique to generate +5 V and +12 V DC is either from DC battery or rectified AC via diodes to produce continuous power supply. In this research, method of rectifying A.C voltage was used. To obtain +5 V and +12 V D.C from the mains 220V A.C, it requires the use of 12V step down transformer and convert it from alternating current to pulsating direct current, using diodes arranged in square. A smoothing filter (usually a capacitor) was used to remove the ripples to pure DC voltage. The voltage is regulated using 7805 and 7812 voltage regulators to ensure constant +5V and +12V D.C supply to the circuits, respectively.

2.4 Experimental Setup and Microcontroller Embedded Language Development

The ESP8266 positive terminal was connected to the positive of power supply while the GND pin of ESP8266 was also connected to the GND of power supply. The output of each sensor was interfaced with D5, D6, D7 and D8 of ESP8266 while their Vcc pins were connected to output +5V power supply and their GND pins were also connected to 0V of power supply respectively as shown in Figure 3. The source code of this work was programmed in Arduino integrated development environment (IDE) and compiled. The *hex* file was loaded in microcontroller's Flash memory. The microcontroller executes the *hex* file generated by the compiler. The executable code comprised of sequence of zeros and ones organized in 12-, 14- or 16-bit wide words, depending on the microcontroller's architecture. Every word is considered by the CPU as a command being executed during its operation. For practical reasons, as it is much easier to deal with hexadecimal number system, the executable code is often represented as a sequence of hexadecimal numbers called a *Hex* code. For Arduino microcontrollers, programming word comprised of 14 bits wide. The main advantage of C languages is its simplicity, it is no longer possible to know exactly how each command executes when using C compiler. The hardware weather station and the Arduino compiler window are shown in Figures 4 and 5, respectively.

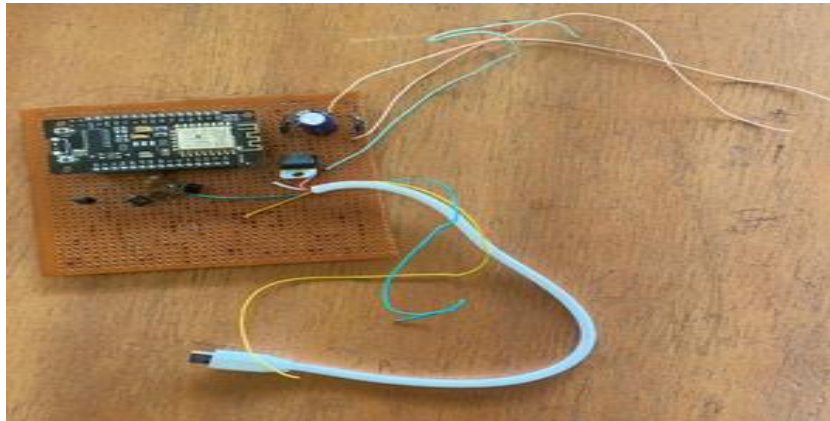


Figure 3: Esp8266 and Power Section

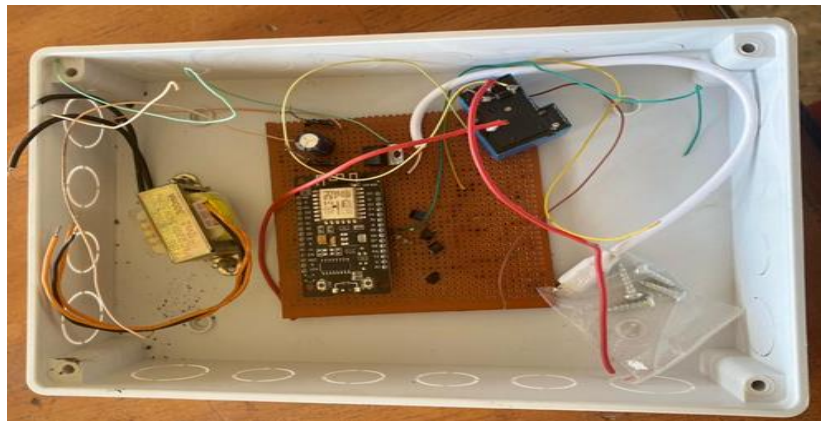


Figure 4: Weather Station Hardware Design

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weather_station_lawal | Arduino 1.8.9
File Edit Sketch Tools Help
weather_station_lawal

#include <SFE_BMP180.h>
#include <EEPROM.h>
#include <ESP8266WiFi.h>
#include <FirebaseArduino.h>
#include <ArduinoJson.h>
SFE_BMP180 bmp180;

#define FIREBASE_HOST "akilapaiot.firebaseio.com" //Your Firebase Project URL goes
#define FIREBASE_AUTH "xdOpRR7zD7IRdNhQEiSD8nIWbmT8e4m0Ytuqv2ET" //Your Firebase
//define WIFI_SSID "itelA32F" //your WiFi SSID for which
//define WIFI_PASSWORD "graceofgod" //Password of your wifi network
#define WIFI_SSID "Zikoleo" //your WiFi SSID for which yo
#define WIFI_PASSWORD "253512ola"

#include <LiquidCrystal_I2C.h>
#include <Wire.h>
//define encoder 0
LiquidCrystal_I2C lcd(0x27, 16, 2); //3F
float count =0;
//float i;
int addr=0;
    
```

Figure 5: Arduino IDE Block Code

3. RESULTS AND DISCUSSION

The concept of this study is to use IoT to design weather station to measure climate condition in an open environment such as agriculture area. The system was tested on different weather conditions such as temperature, humidity, light intensity, volume and pressure. The result obtained using real time database for the testing of the system was displayed on mobile phone as shown in Figure 6. Each module in case of the software were tested to know whether it performs the functions assigned to it and also to know whether each of the module can interact as required by transferring and returning data in form of a signal. The system was further tested on different time frame for temperature, humidity, light intensity, pressure and water volume. The obtained data results were analysed as shown in Table 1.

At 7am, the temperature reads 19°C, humidity reads 27%, light intensity recorded 1019, air pressure reads 95134 and water volume recorded 0. At exactly 1:19pm in the afternoon, the temperature has risen to 30°C, humidity recorded 42%, light intensity recorded 200, air pressure reads 95165 and water volume reads 23. The results obtained for the selected location prove better such that, early in the morning the temperature maintain a minimal value (cold weather) but got increased when the weather gets hot and the humidity, air pressure change state respectively. The water volume depends on the amount of rain within the time frame but from the result in Table 1, it indicates amount of water dropped in the rain gauge. The results of the collected data were represented using column graph as shown in Figure 7, the graph helps to analyze the data collected for further assumption. The system was successfully tested on different farm environment, thus proving its portability and wide compatibility.

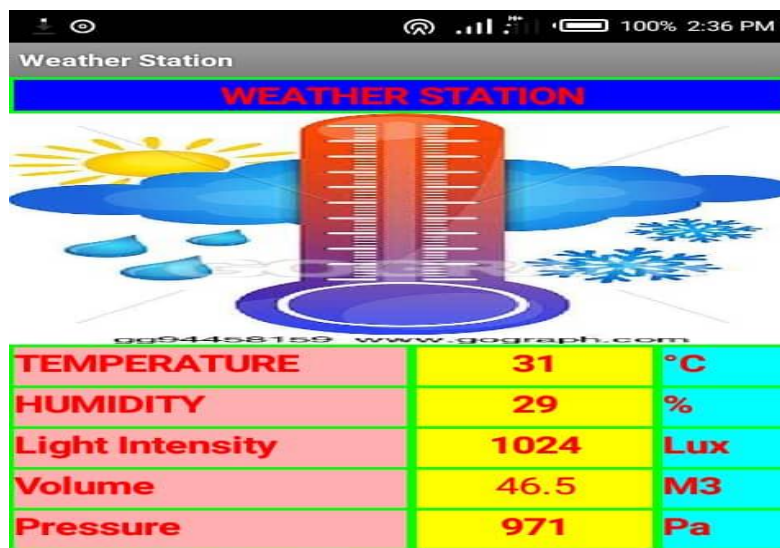


Figure 6: Weather station result output on android app

Table 1: Weather Station Result Output (28th January, 2022)

Time	Temperature	Humidity	Light Intensity	Air Pressure	Water Volume
7:00 am	19	27	1019	95134	0
7:30 am	21	30	1001	95138	5
9:20 am	24	34	980	95141	11
11:30 am	26	37	600	95153	17
12:00 pm	28	39	300	95160	20
1:19 pm	30	42	200	95165	23

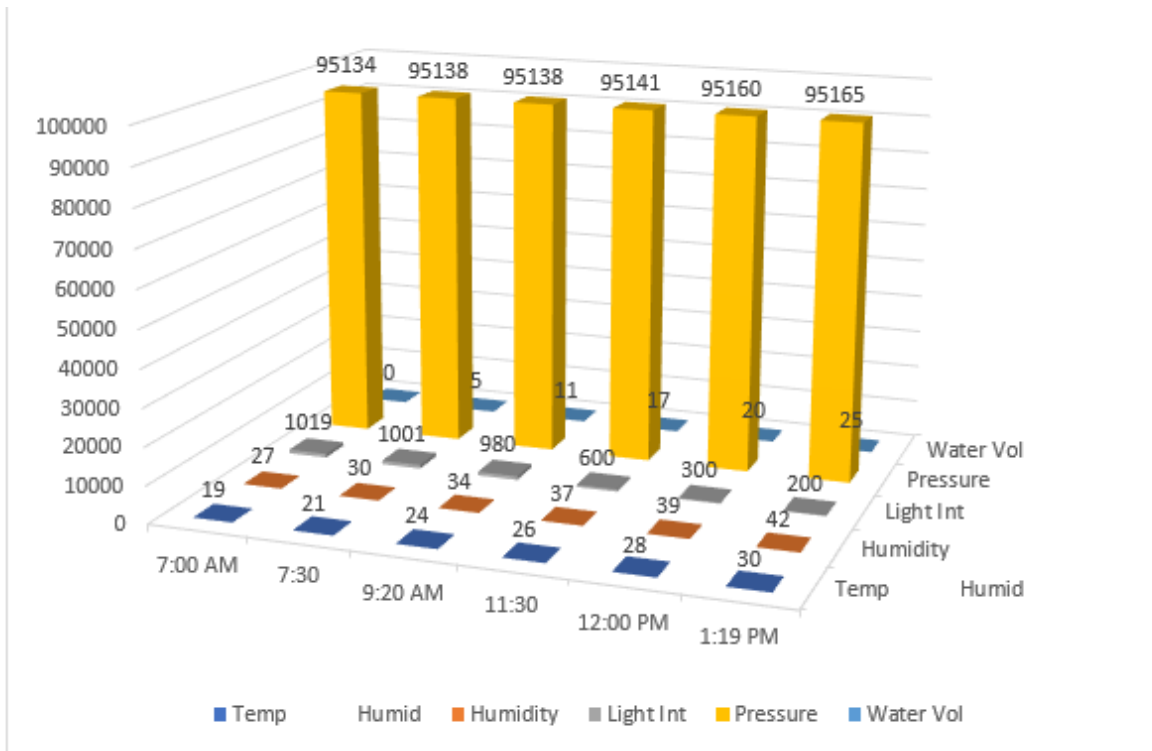


Figure 7: Result Analysis for Weather Station Parameters

4. CONCLUSIONS

Weather station has been experimentally proved to work effectively and efficiently with available resources. The system was successfully tested on a multitude of different farm environment, thus proving its portability and wide compatibility. Internet of things (IoT) was successful in fetching data from sensors (DHT11) that compute the temperature and humidity, rain gauge that compute volume of rain fall, LDR that compute light intensity and BMP180 that compute value of pressure. The data from each of the sensors were sent to the firebase database used to store data at regular intervals. Thus, weather station was successfully designed, implemented and tested. The result obtained showed that the system can be deployed for monitoring of agricultural products. This study has been able to develop a system that involved in acquiring weather and environment data using advanced electronic sensors. The system developed provides ease of monitoring local weather conditions in real time. The system also accommodates storage of weather and environment data for short and long term and for studying weather pattern changes for agriculture process.

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