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Research Article

A Novel Agriculture Tracking System Using Data Mining Approaches

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Abstract

Agriculture has been one of our most important needs in the world since the first ages. Nowadays, human knowledge and experience, especially in agriculture, are still lacking in achieving the most productivity. For a plant to grow close to 100% yield, multiple variables must be in optimal condition. In the Agriculture Tracking System, people are able to control the environment required for growing plants, i.e. optimal levels of their variables. Therefore, in this study, we have designed a hardware system with an Internet of Things (IoT) device and 2 sensors. The solar energy to power this hardware system has been used. Also, these sensors are a digital humidity and temperature sensor (DHT11) and Soil Moisture Sensors. Values of incoming from sensors are read with an IP Address. Moreover, these values are written to SQLite database and displayed last 5 records with bar charts. The users can save plants with optimal values. With these values, can make predictions. We have studied the effect of the sun angle on temperature and humidity in the last 5 years with months. We have compared this data with the plants added by the user and presented the most appropriate and closest months as a warning to the user. Another prediction is possible with instant records. When we researched, we saw that the condition of the plant can be categorized according to temperature and humidity. By checking the instant data, a warning message to the user according to these rates is sent by using the K-Nearest Neighbour classification algorithm. As a result, in the tests, the results have shown that this approach can increase productivity.

Anahtar Kelimeler: E-agriculture, Internet of things, Data mining, Mobile Applications.

Veri Madenciliği Yaklaşımlarını Kullanan Yeni Bir Tarım Takip Sistemi

Öz

Tarım, ilk çağlardan beri dünyadaki en önemli ihtiyaçlarımızdan biri olmuştur. Günümüzde, özellikle tarımda insan bilgisi ve deneyimi yine de en verimliliğe ulaşma konusunda eksiktir. Bir bitkinin %100 verime yakın büyümesi için, birden çok değişkenin optimum durumda olması gerekir. Tarım Takip Sisteminde insanlar bitki yetiştirmek için gerekli ortamı, yani değişkenlerinin optimum seviyelerini kontrol edebilmektedir. Bu nedenle, bu çalışmada Nesnelerin Interneti (IoT) cihazı ve 2 sensör içeren bir donanım sistemi tasarladık. Bu donanım sistemine güç sağlamak için güneş enerjisi kullanılmıştır. Ayrıca, bu sensörler Dijial Nem ve Sıcakık (DHT11) ile Toprak Nemi sensörleridir. Sensörlerden gelen değerler bir IP Adresi ile okunur. Bu değerler SQLite veritabanına yazılır ve son 5 kayıt çubuk grafiklerle görüntülenir. Kullanıcılar bitkileri optimum değerlerle kaydedebilirler. Bu değerler ile tahminlerde bulunabilir. Bununla beraber, son 5 yılda güneş açısının sıcaklık ve nem üzerindeki etkisini aylarla birlikte inceledik. Bu verileri kullanıcı tarafından eklenen bitkilerle karşılaştırarak en uygun ve en yakın ayları kullanıcıya uyarı olarak sunduk. Anlık kayıtlarla başka bir tahmin mümkündür. Araştırdığımızda bitkinin durumunun sıcaklık ve neme göre kategorize edilebileceğini gördük. Anlık veriler kontrol edilerek K-En Yakın Komşu sınıflandırma algoritması kullanılarak bu oranlara göre kullanıcıya uyarı mesajı gönderilir. Sonuç olarak testlerde elde edilen sonuçlar, bu yaklaşımın verimliliği artırabileceğini göstermiştir.

Keywords: E-Tarım, Nesnelerin interneti, Veri madenciliği, Mobil uygulamalar.

1. Introduction

Agriculture has been one of our most important needs in the world since the first ages. The agricultural sector, which affect an important role in the development of countries and societies has experienced great developments with modern technology. Nowadays, human knowledge and experience may be lacking, especially in agriculture. For a plant to grow close to 100% yield, multiple variables must be in optimal condition. With agriculture tracking system, people are able to control the environment required for growing plants, i.e. optimal levels of their variables. This study has GPS based remote controlled monitoring. In addition, it includes the issue of security by scaring intruders, temperature detection, leaf moisture and suitable irrigation facilities. The sensors of this control system are placed in various parts of the farm and they are communicated using the Wi-Fi network. The control of these measurement parameters is done by any remote device or internet service. All operations are carried out through the management of the database obtained by collecting the data transmitted by the sensors via Wi-Fi communications on the central server with a mobile application and user-friendly interfaces. This prototype product is designed for easy use by farmers and to increase efficiency in agriculture. The difference of this study from my study is using camera with microcontroller (Suma et al., 2017).

This study aims that; the only solution is intelligent agriculture by improving the existing conventional approaches of agriculture for improvement of countries like agriculture tracking system. It focuses on all agriculture problems. Like operations to weed, spray, sense moisture, scare bird and animal, keep vigilance, etc. This study includes GPS based remote controlled robot to perform these tasks. This is the main difference between for this study. Smart warehouse management which includes temperature maintenance, humidity maintenance and theft detection in the warehouse. Intelligent warehouse management includes temperature and humidity maintenance, and theft detection in the agricultural areas. Implementation of all these operations means that using remote intelligent devices, servers, and clients connected to the network connection. The usage of Wi-Fi modules, cameras, actuators with microcontrollers, and interfacing sensors, implement these structures. We think, it cannot be useful for every situation. Especially, GPS based remote controlled robot (Gondchawar & Kawitkar, 2016).

In this study, they focus anticipation for many variables. The smart irrigation system determines the appropriate irrigation time and irrigation period using the air temperature, air humidity and soil moisture. The smart irrigation system uses many sensors like agriculture tracking system. The big difference is; the system uses sensors for estimating the precipitation. Developed android-based user interface provides real-time display of data such as sensor data, irrigation time, electricity and water consumption. In the agriculture tracking system, we will develop android-based user interface too (Taştan, 2019).

In this study, to increase yield in greenhouses, necessary to measure and evaluate the environmental values and to adapt the environmental conditions according to the grown product. Accomplish all these parameters are an important part of the controlled greenhouse environment. In this work, an Internet of Things (IoT) based system was developed, with low-cost Raspberry Pi single board computer and ESP8266 Wi-Fi modules. With this system, the temperature and humidity values, soil moisture, air quality and light values of the greenhouse taken from wireless sensors. And after that, recorded and can be monitored with remote access. Thus, where the values taken from the sensors exceed the lower and upper limit values determined, the user can be notified by email and short message (SMS) (Baysal et al., 2018).

In this study, three problems are described. These are concerning agriculture, countryside and farmers. It said that, the solution is agricultural modernization. This study believe that it is possible with cloud computing and IoT. The aim of this study is automating the whole agricultural area (TongKe, 2013). When we checked to related works, we understand that most of researchers focused on sensors. Generally, they read data from the sensors. After that, these data were shown to a screen. On the agriculture tracking system, users can know critical points. They don't always have to check or follow. With IoT, they can follow the situation with a warning message of critical moments wherever they are. And, their study s should have any energy. Their energy is generally battery. We believe that, this is not useful for every situation. That's why, agriculture tracking system has solar power. It generates its own energy itself.

In the literature, it can be seen that the amount of sunlight determines the development of plants. The germination of the seeds of many plants is the most important factor for budding and yield. At the same time, the sun's rays affect the values such as angle and duration, temperature and humidity. For this reason, in my study, we based the monthly sun angle, duration, average temperature and humidity values of a city. With these values, we can predict the most productive months when plants can be planted. In study, agriculture tracking system is aimed to keep to optimal condition, keep track of the variables that a plant needs to grow and prediction optimal situations. Users can check possible status and receiving warning messages at critical moments. In addition, the system can produce energy to own energy.

Firstly, this system should have less equipment. It should be practical. Working area is soil surface. That's why, it is able to work under all conditions. In hardware, it has more than one sensor and a solar panel for solar energy. To communication between user and the system, it has an IoT system. In software, it has a database that has many variables for optimal values to plants need to grow. It saves states that occur over time intervals. Also, the agriculture tracking system has a mobile application for the messages and following.

Most important point is sensors, solar power and Wi-Fi module. We will use Arduino IDE. Like humidity sensors and temperature sensors are check to optimal values. ESP8266 Wi-Fi module for the communication between sensors and people. The question is that where will the system get energy. It is possible with a solar panel.

In addition, we will use SQLite for database management system. For mobile application, we will use Android.

2. Related Works

The work is related to the application of IoT technology in the agricultural system. It used mobile wireless communication technology to monitor the greenhouse area. Internet and wireless communication were used together for the remote monitoring system. At the same time, an information management system has been planned. Data collected by the system was used for agricultural research and management.

As a result, it has realized automatic control over ambient temperature and humidity values for ambient tracking. This system is easy to use. It offers users real-time environmental factors in the greenhouse with a good interface. It can control environmental variables and do whatever it wants to do online. It works reliably, shows high performance, and develops easily (Zhao et al., 2010).

This work designed an efficient agricultural production system using IoT technology and applied as GUI visualization software. Product and environmental information using correlation analysis The IoT based agricultural production system attempted to analyze the user's current conditions and predict future product as shown in Figure 1. In addition, the quality of agricultural products can be improved. The reason is obvious, the person concerned observes the whole cycle from seeding to sale using this IoT based agricultural production system (Lee et al., 2013).

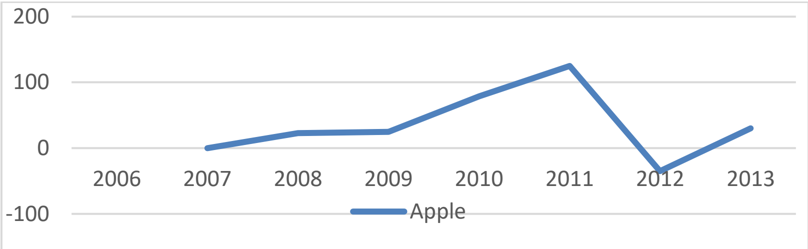


Figure 1. A year-on-year increase in Apple acreage by result of agricultural production system (Lee et al, 2013)

In this study, there are various features such as remote monitoring by GPS, tracking of humidity and temperature values, removal of harmful objects for safety, leaf wetness rate and appropriate irrigation method. Wireless sensor networks are used to continuously monitor soil properties and environmental factors. Different sensors are placed in different locations in agricultural areas. To control these sensor values, a remote device or an internet service is carried out with sensors, Wi-Fi, camera with microcontroller. Thus, the workload of the farmer is reduced and quality products are grown (Suma et al., 2017).

The purpose of Hanschke's study is that a more convenient port route is required in a port area due to increased shipping volume. For this target, deploying wireless sensors and actuators to realize a cyber-physical port. On the other hand, many sensors and actuators required the device to be upgraded to two main challenges. The first challenge is that the external power supply infrastructure does not have affordable and flexible conditions. Therefore, it is not useful. The second challenge is that some devices connecting to the internet require additional infrastructure, which makes it complex. With this research, low-power IEEE802.11 Wi-Fi based devices may be possible to communicate. It is reliable with solar power, existing or planned Wi-Fi access points. As a result, they demonstrated power compatibility of a small-sized, low-power energy machine with the Arduino MKR1000 and similar Wi-Fi nodes (Hanschke et al., 2016).

In Khanna's study, it is an integrated system that includes solar energy module and electricity, electronics and programming. This research required 2 basic devices. These are Wi-Fi and Bluetooth devices. Android apps provide a simple, convenient interface for control and monitoring. The Bluetooth application and Arduino compiler were used to start and control the D.C motor. Also, the D.C motor can be controlled from a Bluetooth device within a range of several meters. It also responded appropriately to all commands in the Bluetooth module of mobile applications (Khanna, 2015).

In this study, he tests and analyzes an electronic circuit that can be used as a solar portable charger for cell phone devices that use solar energy as an electricity source. A small size solar cell panel was chosen as it is easy to carry anywhere. This method solves the problems in emergency situations outside and goes beyond traditional methods. As a result, there are many important recommendations in this study. The first is that solar energy can be actively used as an alternative power source to charge mobile devices. For maximum absorption of solar energy, the direction of the panel should be perpendicular to the direct line of sight or sunlight. Second, the proposed electronic design is easy to implement practically with low cost electronic components, and the selection of suitable components (Zener diodes, Darlington transistors, etc.) is important to obtain the desired voltage and charge current levels (Attia et al., 2014).

This work is to develop a prototype of the building lighting remote control system. It can monitor and control the lighting remotely with the web application. This remote control system allows users to save electricity for building lights. For this remote control system, voice recognition has been developed as a controller of electrical equipment. Arduino UNO and EasyVR module are combined as a voice recognition module. An Arduino based smart home remote control system controlled via an Android smartphone was designed. With them, users do not need to work directly on the electrical appliance. A module that controls the electronic device using the Raspberry Pi as an online web server has also been developed. This module can be controlled using a PC or Smartphone. Figure 2 shows the final prototype before installing it in the building. A single light and a fan were used in the prototype. The test starts with the lights on and is done by running a web application and accessing it from smartphones and computers. As a result, they found that using the Raspberry Pi Mini PC as the web can reduce power consumption by 25%. While Arduino was widely used as a microcontroller in the previous research, this research used the NodeMCU as the microcontroller as it can connect directly to Wi-Fi. Its size is also smaller than Arduino, so it used less electricity consumption compared to other microcontrollers (Handayani et al., 2019).

Figure 2. The develop prototype (Handayani et al., 2019)

In this study, the design and development of a low cost Arduino based advanced solar battery charge controller is presented. The Maximum Power Point Tracking (MPPT) algorithm is applied to charge the battery. The charge controller has a battery management system with Liquid Crystal Display (LCD) and Wi-Fi module for data logging and storage. When various limits are reached by the system, the charge status of the battery is monitored and cut off. The improved battery charger will help better monitor battery performance and system reliability. Figure 3 gives the block diagram of the proposed system (Kaur et al., 2016).

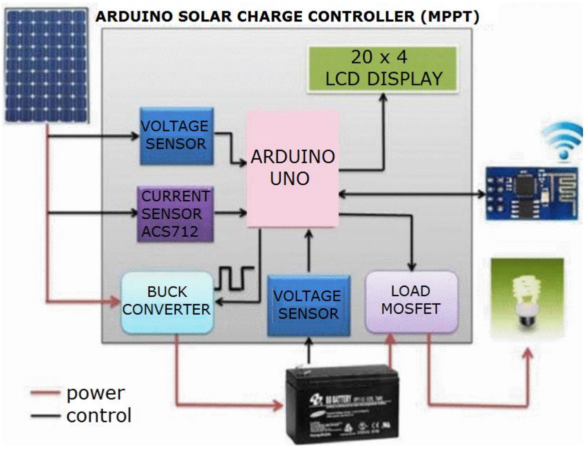


Figure 3. Block diagram of the proposed solar system (Kaur et al., 2016)

This work focus on battery energy storage systems. These systems can absorb and transmit both real and reactive power with sub-second response times. Many problems can be reduced with these capabilities. Such as frequency, voltage issues and ramp speed. Energy storage control systems can also be integrated with energy markets to make solar resource more economical. This study presents the integration of solar energy into electricity distribution system, battery energy storage systems and shows various modes of operation for battery energy storage systems in grid-connected solar energy applications (Hill et al., 2012).

In this study, the renewable energy source aims to obtain the most efficient electrical energy from solar energy. At every hour of the day, the angle of arrival of the sun's rays changes. It will not be fully efficient in the energy obtained from the fixed solar panel. The movement of the panel in horizontal and vertical directions is provided so that the angle of the solar rays coming to the solar panel is perpendicular. Arduino microcontroller board is used to control the movement and control of the panel. The value of the electricity generated during the day is controlled by the voltmeter circuit (Barış et al., 2017).

3. Materials and Methods

3.1. Hardware Part

Electricity supply is difficult and important given the environmental factors in agricultural areas. The Agriculture Tracking System supports to natural resources. Arduino provides the necessary energy source with solar panel. As shown in Figure 4 solar energy charging batteries. After that, these batteries are getting power supply for Arduino. Wi-Fi module is ESP8266. The data from sensors sends data to a database on computer with this module. Finally, sends the data to the mobile application that the user can follow and gives warning messages.

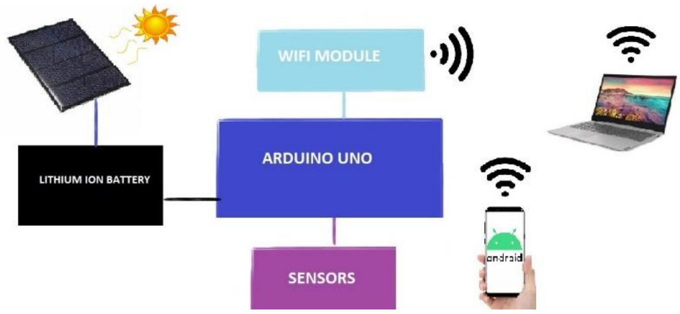


Figure 4. Architectural view

The most important feature of the Agriculture Tracking System is that it provides the necessary energy itself. It is possible with solar energy. As shown in Figure 5, solar panel is charging to lithium ion batteries. They are 3.7V. It needed to voltage regulator. Because Arduino's required energy cannot be 3.7V. That's why, we use LM7805 voltage regulator. Also, for connection between solar panel and lithium ion battery is needed TP40056 Lithium Battery Charger. Its' output can be energy for Arduino.

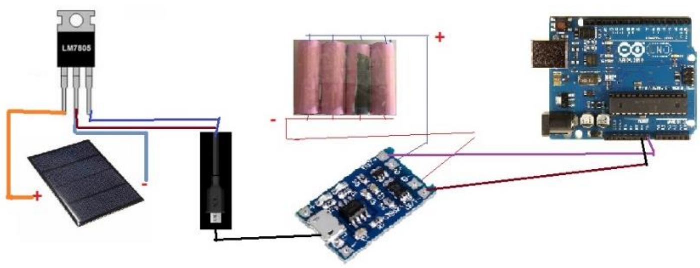


Figure 5. UI Design for Arduino's energy

Temperature / Humidity Sensor (DHT11) and Soil Moisture Detection after programming with Arduino. This communication is possible with the library. After this system, the database reads the data from the IP address of the IoT. Wireless Communication System (ESP8266). As shown in Figure 6, the use of the Agricultural Tracking System is ready for use in the mobile application.

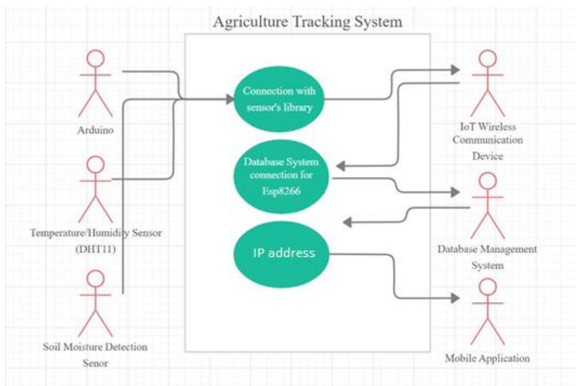


Figure 6. Use cases

Dht11: Temperature and Humidity Sensor has several types. We am going to use DHT11 Sensor Module as shown in Figure 7. It has three pin that generates calibrated digital output. It's power supply is between 3.3V and 5.5V. DHT11 Sensor has 4 pin that NC. The only difference between sensor and module is that the module has an internal filtering capacitor and lift-off resistor, and you have to use them externally for the sensor if needed. Both of them perform the same.

Figure 7. DHT11 with pins, Soil moisture module is placed in the soil, Soil Moisture Module main part

Soil Moisture Sensor: The Soil Moisture Sensor Module can be used to detect the moisture of soil or judge if there is water around the sensor. The working voltage of 3.3 V to 5 V. It consists of two parts. To insert one module into the soil and another to adjust the on-board potentiometer to adjust the sensitivity. And also, it works digital or analog outputs. In this module, it has two pins. They are positive and negative pins. But it does not matter which one is positive and negative. As shown in the Figure 7, the green and blue cables connect to another module. As shown in Figure 7, this module is important. It has four pins. They are analog output, digital output, GND and VCC. We use Analog output.

ESP8266: ESP8266 is a device used in IoT technology. The biggest feature is that cheap and easy to use. It widely used for these reasons. The working voltage is 3.3 V. The easiest way to connect Arduino to the internet. When we work on this study, we saw that do not need to ESP8266 and Arduino. They have energy cost for the study. And also, the hardware of ESP8266 is a bit complicated. As a result of my research we saw that ESP8266 NodeMCU is more suitable. We can connect to DHT11 Module Sensor and Soil Moisture Sensor directly to ESP8266 NodeMCU.

ESP8266 NodeMCU: The other name of the ESP8266 NodeMCU is the LoLin ESP Development Board - CP2102, which runs on ESP8266 with non-OS SDK and is hardware based on the ESP-12 module. The device features 4MB flash memory, 80MHz system clock, approximately 50k of available RAM and on-chip Wi-Fi Transceiver. Working voltage is 3.3V. Input voltage is 7-12V. As shown in Figure 8, the ESP8266 NodeMCU has a total of 30 pins. There are four power pins VIN. One VIN pin and three 3.3 V pins. The VIN pin can be used to directly power the ESP8266 and peripherals if you have a regulated 5V voltage source. 3.3V pins are the output of a built-in voltage regulator. These pins can be used to power external components. As shown in Figure 8, ESP8266 NodemMCU has one analog pin on the left first side. We am going to use for Soil Moisture Module on here. We am going to use digital output for DHT11 Module. For both sensors, we am going to connect separately with 3.3V and GND from the Wi-Fi module.

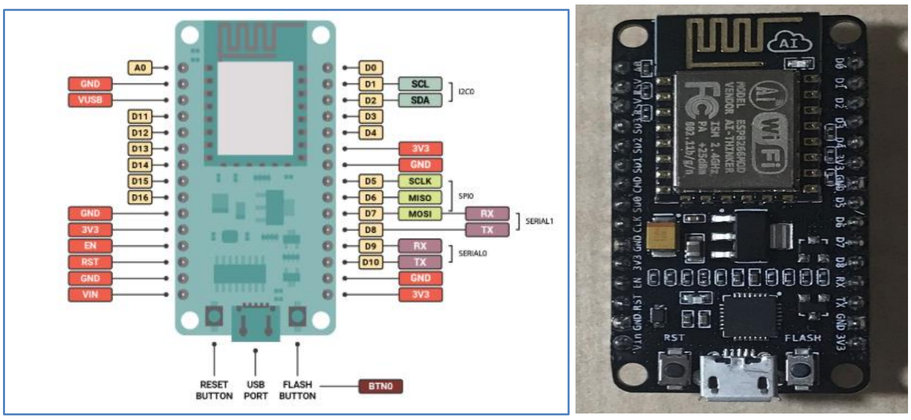


Figure 8. ESP8266 NodeMCU datasheet, ESP8266 NodeMCU

Circuit of The Agriculture Tracking System: We connect to analog pin to Soil Moisture Module and D7 pin to DHT11 Module. As it appears in Figure 9, the voltages of the sensors were supplied separately from ESP8266 NodeMCU. Lithium ion is a type of rechargeable battery. The most important feature is that the battery does not need to discharge completely. It can be charged at any time. We used 4 batteries of my computer battery. We soldered it with a wire, fixing it according to the + and - poles. So we got + and – out as shown in Figure 9. The TLP4056 charger is a very handy, small and very economical product with a micro USB port on it and where you can charge lithium batteries via USB. There is a micro USB connector on it as shown in Figure 10. Power input via micro USB cable can be provided through this connection or feed input via any 5V source via the IN+ and IN- pins on the card can be made. The BAT- and BAT+ pins on the bottom of the card are the battery ports. 3.7 V batteries are connected to these ports and can be easily charged. We used this pins for connection with lithium ion batteries. OUT+ and OUT- pins used for input voltage. The micro USB connector used for solar panel connection. The LM7805 is a three leg positive voltage regulator as shown in Figure 10, giving a constant 5V output. Left leg is input, middle leg is GND and right leg is output. We soldered LM7805's left and right legs with a wire. And also, we connected LM7805 and micro USB.

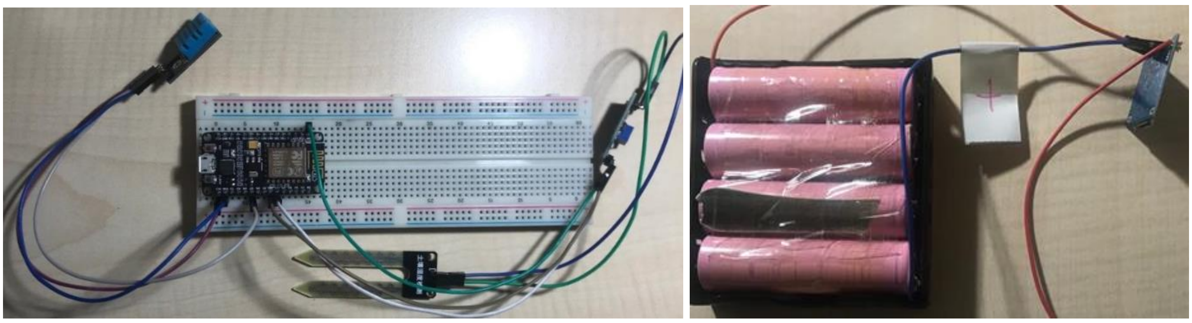


Figure 9. View of the circuit, Lithium ion batteries.

When charging batteries, the solar panel is used. The panel is not connected directly to the ESP8266 NodeMCU that is connected directly to the batteries.

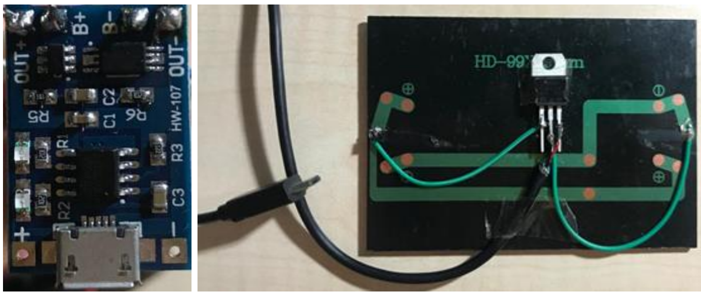


Figure 10. TLP4056, Solar panel with LM7805.

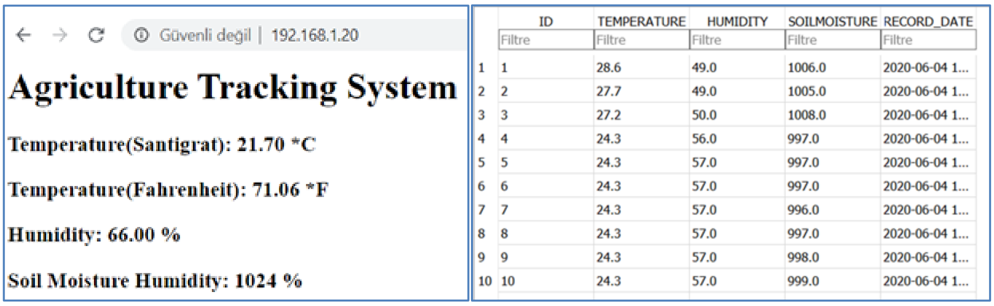
3.2. Software Part

Arduino is an open source electronics platform based on easy-to-use hardware and software. It can be said what to do with your board by sending a series of instructions to the microcontroller on the board. It is simple and accessible user experience. We am going to programming ESP8266 – NodeMCU with Arduino. By programming the ESP8266, we can read and write the data from the sensors both on the Arduino serial port and on the IP address. Thus, it is easy to reach the data. Arduino code has some library. They are ESP8266 Wi-Fi and DHT. The soil moisture module is working on analog pin. That's why, we do not need a library. To add library, followed Sketch – Include Library – Manage Libraries, we searched ESP8266 and DHT11. We downloaded available library. The main feature of the Arduino codes is the sensors were read and the values of sensors were written to Wi-Fi module IP address and Arduino serial port. In any given second, the web page is refreshed with serial port.

```
#include <ESP8266WiFi.h>
#include <DHT.h>

const char *ssid = "Wi-Fi name";   //Wifi ssid and wpa2 key
const char *password = "Wi-Fi password";

WiFiServer server(80);

int DHTPin = 13; //Digital pin for DHT11
DHT dht(DHTPin, DHTTYPE);
void setup() {
 Serial.begin(9600); //bound rate is 9600
 delay(10);
 dht.begin();

 Serial.println(); //Connecting to the network
 Serial.print(ssid);
 Serial.println(" is connecting...");
 WiFi.begin(ssid, password);
 while (WiFi.status() != WL_CONNECTED) {
  delay(500);
  Serial.print(".");
  delay(500);
  Serial.print(".");
 }
 Serial.println("");
 Serial.println("Network successfully connected!");
 // Web server.
 server.begin();
 Serial.println("Web server is working. ESP is expected to receive IP...");
 delay(10000);
 Serial.print("IP: "); // Print ESP's IP address.
 Serial.println(WiFi.localIP()); }
void loop() {
 WiFiClient client = server.available(); // Check for new connections.
 if (client) {
  Serial.println("*New connection*");
  boolean blank_line = true;
  while (client.connected()) {
   if (client.available()) {
    char c = client.read();
    if (c == '\n' && blank_line) {
      float h = dht.readHumidity();// Read humidity.
      float t = dht.readTemperature();// Read temperature centigram.
      float f = dht.readTemperature(true); // Read temperature Fahr.
```

```
      int soilMoisture = analogRead(A0);
       Serial.print("Humidity: ");
       Serial.print(h);
       Serial.print(" %\t Temperature: ");
       Serial.print(t);
       Serial.print(" *C ");
       Serial.print(f);
       Serial.print(" *F\tSoil Humidity: ");
       Serial.println(soilMoisture);
      client.println("HTTP/1.1 200 OK");
      client.println("Content-Type: text/html");
      client.println("Connection: close");
      client.println();
      client.println("<!DOCTYPE HTML>");
      client.print("<html>");// Print the data to web page.
      client.print("<meta http-equiv='refresh' content='20'>");//Page
refresh every 20 seconds
      client.println("<head></head><body><h1>Agriculture Tracking
System</h1>");
      client.print("<h3>Temperature(Santigrat): ");
      client.println(t);
      client.print("*C</h3><h3>Temperature(Fahrenheit): ");
      client.println(f);
      client.print("*F</h3><h3>Humidity: ");
      client.println(h);
      client.print("%</h3><h3>Soil Moisture Humidity: ");
      client.println(soilMoisture);
      client.print("%</h3><h3>");
      client.print("</body></html>");
      break;
    }
    if (c == '\n') {
      blank_line = true; // when the new line starts to be read
    }
    else if (c != '\r') {
     blank_line = false;
    }
   }
  }
  delay(500); // Connection ended.
  client.stop();
  Serial.println("\nConnection ended.");
 }
}
```

When we visit on the given IP address, the screen is as seen on Figure 11. Every 20 second, the address reloads. This value can change. We used Android Studio for my mobile app. Users will be able to view sensor values momentarily and in the past. With Android Studio, after reading the sensor values in my IP address, it both writes to the screen and saves them to the database. We read my IP address using the AsyncTask structure. And also, we chose SQLite for the database. If we checked to the table, we should select table name and right click on that to “Show Table”. We will see a screen as shown in Figure 11.



	ID	TEMPERATURE	HUMIDITY	SOILMOISTURE	RECORD_DATE
	Filtre	Filtre	Filtre	Filtre	Filtre
1	1	28.6	49.0	1006.0	2020-06-04 1...
2	2	27.7	49.0	1005.0	2020-06-04 1...
3	3	27.2	50.0	1008.0	2020-06-04 1...
4	4	24.3	56.0	997.0	2020-06-04 1...
5	5	24.3	57.0	997.0	2020-06-04 1...
6	6	24.3	57.0	997.0	2020-06-04 1...
7	7	24.3	57.0	996.0	2020-06-04 1...
8	8	24.3	57.0	997.0	2020-06-04 1...
9	9	24.3	57.0	998.0	2020-06-04 1...
10	10	24.3	57.0	999.0	2020-06-04 1...

Figure 11. Screen of IP address, Viewing the created table in SQLite Browser.

4. The Application and Tests

As shown in Figure 12, the main screen of emulator. On the screen, user can see instant sensor values. In addition," DISPLAY VALUES " button can see the last 5 records of temperature, humidity, soil moisture values with the bar chart. With the "SAVE NEW PLANT OPTIMAL VALUES " button, the name of a plant the user wants to grow can save optimal temperature, humidity and soil moisture to a database. It can see saved data as a list. With the "THI" button, it gives instant warnings according to temperature and humidity. With the "PREDICTION" button, the user enters plants according to the annual estimates to increase the yield.

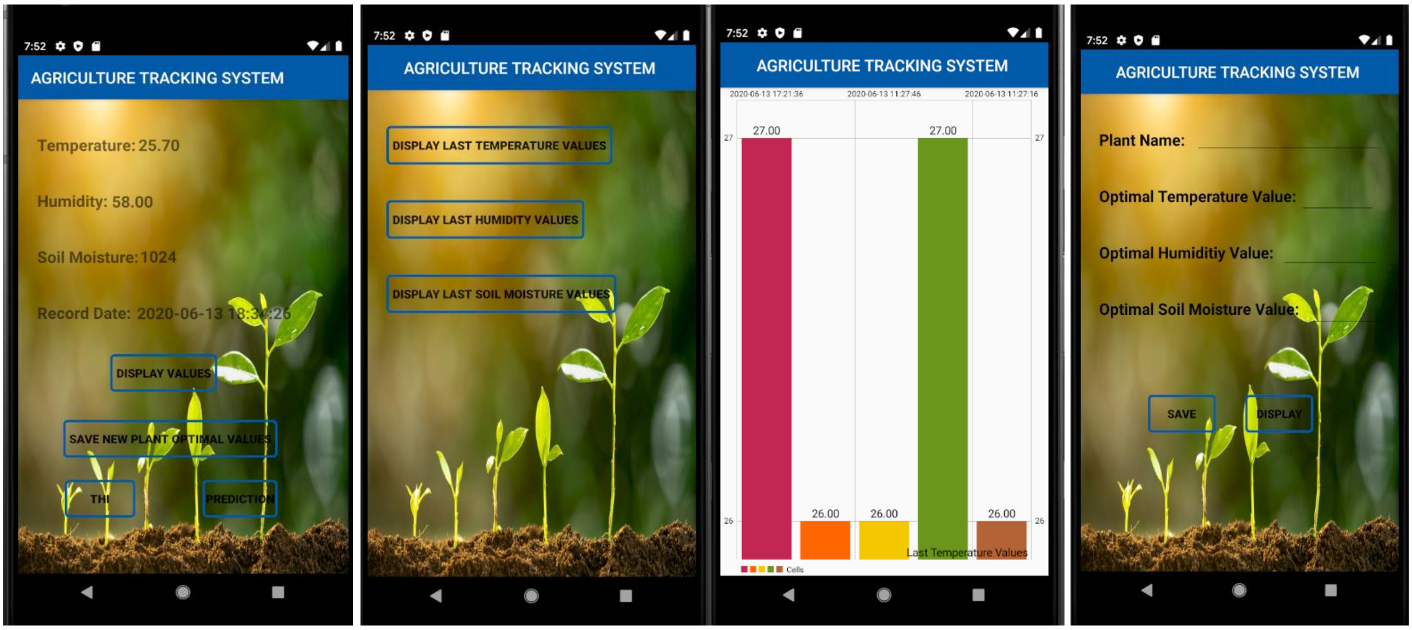


Figure 12. The main screen of the emulator, Display options screen and “Display Last Temperature Values” screen, Inserting to database and displaying.

As shown in Figure 12, there is a screen for the user with options for temperature, humidity and soil moisture. The last 5 records, when users select any one, can observe the situation.

I designed a new interface as shown in Figure 12 and created a database for use in annual estimates for plants. This database has optimal values such as the plant name, temperature, humidity, and soil moisture requirements. The user can enter this information and save the plant in the database with the "Save" button. It can also display the data in the database with the "Display" button.

When we researched for prediction, we saw that the amount of sunlight determines the development of plants. It is the most important factor for germination of the seeds of many plants, opening of the buds and giving yield. The angle of sunshine, its amount depends on the movement of the sun, the properties of the soil and the climate. The sun's rays and temperature are also directly related. Temperature varies according to various times of the day and seasons. The reason for this is that the sun's rays sometimes come with an oblique angle and sometimes with a right angle according to these factors.

$$\cos\Theta = \sin\sigma \sin\Phi \, conS - \sin\sigma \cos\Phi \sin S \cos\varpi + \cos\sigma \cos\Phi \cos S \cos w + \cos\sigma \sin\Phi \sin S \cos y \cos w + \cos\sigma \sin S \sin y \sin w \quad \text{Eq. 1}$$

Latitude angle (Φ): from the ground with the equatorial plane between the radial line to the center of the Earth the angle is. The latitude takes its positive value for the northern hemisphere and varies between 90º and 90º.

Clock angle (w): is the angular measure of time and is a clock 15º longitude equals. Angle plus and noon before noon then it gets a minus. For example, angle + for 10.00am For 30º and 15.00 - 45º.

Slope angle (S): between horizontal surface and oblique surface the remainder is the angle. Plus value for surface facing equator it takes. (Yücel et al., 2018)

WE've created a new database with this information. The columns of this database consist of year, month, sun arrival angle, monthly sunbathing time, temperature effect, moisture effect and soil moisture effect. We tried to find the values of Izmir province with got help from the meteorological site.

K-nearest neighbors (KNN) algorithm is a type of supervised Machine Learning algorithm which can be used for both classification as well as regression predictive problems. It uses feature similarity to predict the values of new data points which further means that the new data point will be assigned a value based on how closely it matches the points in the training set. We was inspired by this algorithm to estimate whether the plants that the user wants to grow are suitable. As shown in Figure 5.43, the user had added two plants. First one is tomato and second one is cucumber. After calculation, we can understand that cucumber is more suitable for this area. Which month or months are more efficient is written to the screen as a warning. It also makes suggestions for the nearest month by looking at the instant date.

At tests, firstly, we worked with Arduino Uno. All sensors and ESP8266 module are connected to Arduino Uno. But we have seen some disadvantages of using sensors with Arduino Uno and ESP8266. First, the circuit was more complicated. Connecting the ESP8266 module to the sensors as an analog and a digital was more difficult to program. We used ESP8266 NodeMCU to make the circuit smaller and easier to apply. So we didn't have to use Arduino UNO. We programmed it by connecting sensors directly to ESP8266 NodeMCU.

When we worked on ESP8266 NodeMCU device, my DHT11 module burned. We saw that downloaded driver of CP2102 had deleted. For working with ESP8266 NodeMCU device, you should download CP2102 driver. It is very important. To read IP address, the application must connect to internet. Therefore, AndroidManifest.xml file is added uses permissions. These codes did not enough to read my IP address. We got an error: "Cleartext HTTP traffic to 192.168.1.20 not permitted at com.android.okhttp.HttpHandler$CleartextURLFilter.checkURLPermitted(HttpHandler.java:124) at com.android.okhttp.internal.huc.HttpURLConnectionImpl.execute(HttpURLConnectionImpl.java:462). We searched many times, we learned that should be added to android:usesCleartextTraffic="true" code in AndroidManifest.xml file. Also, we tried to change my IP address with "https://" instead of "http://". It was not a solution.

5. Conclusion

Agriculture has been one of our most important needs in the world since the first ages. Nowadays, human knowledge and experience may be lacking, especially in agriculture. For a plant to grow close to 100% yield, multiple variables must be in optimal condition. In the Agriculture Tracking System, people are able to control the environment required for growing plants, i.e. optimal levels of their variables. We have designed a hardware system with IoT device and 2 sensors. We use solar energy to power to this hardware system. Also, these sensors are DHT11 and Soil Moisture Sensors. Values of incoming from sensors were read to IP Address. These values are written to SQLite database and displayed last 5 records with bar charts. At the same time, the users can save plants with optimal values to database. With these values, can make predictions. We have studied the effect of the sun angle on temperature and humidity in the last 5 years with months. By creating a new database, we added its effect on the year, month, incoming sun angle, sun exposure time, temperature, humidity and soil moisture. We compared this data with the plants added by the user and presented the most suitable and closest months as a warning to the user. Thus, the user will be able to grow suitable plants, except when he is used to it. Another estimation is possible with instant recordings. When we researched, we found that the condition of the plant can be categorized by temperature and humidity. We check the instant data and send a warning message to the user according to these rates.

Agriculture Tracking System is a study that is very open to development. In the study, the user can only receive data from the sensors, it means that works unilaterally. However, in the future, user can perform an operation using the app. For example, when users want to water, can send this request to new sensors. Another innovation is that the users can automatically guess the appropriate plant with a defined database without entering the optimal values of the plant.

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