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Monitoring of submersible pumps using ESP32 microcontroller and photovoltaic panels

Zaidan Didi, Ikram El Azami
Department of Chemistry, Faculty of Sciences, Computer Science Research Laboratory (LaRI), Ibn Tofail University, Kenitra, Morocco

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ABSTRACT

In this article, the Moroccan climate is currently undergoing several changes that have negatively affected agricultural activities, especially in the field of irrigation. That's why we relied on internet of things (IoT) technology to overcome these problems. In this article, we present the design and realization of an intelligent irrigation system via a solar submersible pump. We used the ESP32 microcontroller which reads the temperature and humidity values measured by the soil moisture sensor. The communication between the blocks is ensured by the radiofrequency module. We have implemented a Web server to monitor the measured quantities. The graphical representation of the data will be ensured using the ThingSpeak platform which makes it possible to store and collect the data coming from the sensors via the hypertext transfer protocol (HTTP). Our achievement was executed and tested without any problems detected, which shows that our smart irrigation study was very successful.

Corresponding Author:

Zaidan Didi
Department of Chemistry, Faculty of Sciences, Computer Science Research Laboratory (LaRI)
Ibn Tofail University
Kenitra, Morocco
Email: zaidan.didi@uit.ac.ma

1. INTRODUCTION

Modern irrigation is currently undergoing a major evolution as it has become a decisive factor in water conservation. In this article, we propose a method for designing and building a remote supervision system for smart irrigation to efficiently manage a solar submersible pump, our irrigation system is based on an ESP32 microcontroller and via a sensor Soil moisture, allows essential parameters such as temperature and soil moisture to be measured effectively, this system will feature connectivity allowing the farmer to monitor these quantities in real-time on a dynamic web interface (PC or Smartphone), or receive SMS or Email notifications to efficiently operate this pump and significantly save water this study is based on the use of radiofrequency modules as the main communication element between the different blocks of this design [1].

2. RELATED WORK

In recent years, several effective studies have shown that there is a rapid and high demand for water [2], [3]. We have also noticed that there has been an intense shift from traditional irrigation to smart irrigation based on Internet of Things technology to fully automate and remotely examine water requirements [4], [5]. In this axis, an interesting study based on the internet of things and image processing was developed, in this study, the researchers hoped that this intelligent system will improve the method of breeding Phalaenopsis in the future [6]. Other intelligent scientific achievements have been developed whose primary purpose is to save water, these studies have integrated android applications with Arduino microcontrollers [7]-[9]. In the same vision, other studies have produced a device based on the internet of things with the integration of sensors, this technique makes it possible to analyze the flow of transmitted data to establish a certain level of performance and security, in sending important SMS and Email notifications in real-time to farmers to make decisions to properly monitor irrigation [10]-[12].

3. MATERIALS AND METHOD

3.1. Hardware part

The article presents a hardware design comprising a solar submersible pump equipped with a photovoltaic panel and three solenoid valves. This solar pump system is further augmented with the integration of a charge controller and a water tank, as illustrated in Figure 1. The solar submersible pump is designed to extract water from a water source using energy from the sun, while the photovoltaic panel serves as the primary power source for the pump. The solenoid valves, on the other hand, regulate the flow of water and ensure efficient water usage.

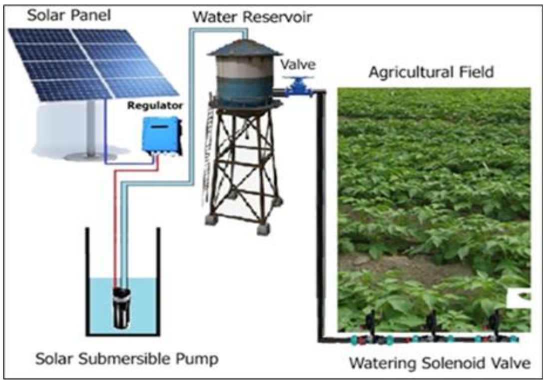

Figure 1. Solar submersible pump design

The material design also includes the ESP32 microcontroller which plays the main processing role by reading the quantities measured by the soil moisture sensors [13], this microcontroller will help us create a web server with a dynamic web page [14]. Our study proposes radio frequency communication, this technique has advantages especially in isolated places, with no internet connection, no GSM network coverage, and "Example of several regions of the Moroccan countryside" That is why we have adopted this alternative solution. In this study, we integrated a “transmitter or receiver” radio frequency module directly linked to Block 1 with the ESP32 microcontroller, we have also implemented an random forest (RF) transmitter module three soil moisture sensors and an Arduino Uno board, in Block 3 of our production, we have also integrated an Arduino UNO board and three solenoid valves and a Radiofrequency receiver module, see Figure 2.

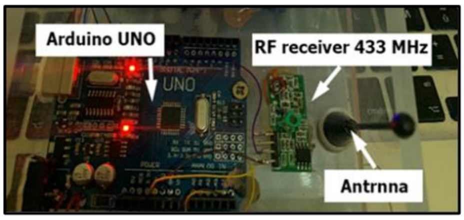

Figure 2. Arduino board with the RF receiver module

We have also set up an RF transmitter module, our monitoring system is efficient thanks to the following privileges: Easy installation and maintenance, remote monitoring - secure communication, finally, the transmission of data with radio frequency technology is very important in isolated places. On the other hand, we studied signal propagation to improve the cover space. Thus, the attenuation of the wave between the transmitter and the receiver is defined by (1) in [15]. Figure 3 shows the attenuation of radio wave diffusion.

$$PL_{dB} = 10\, log_{10}\left(\frac{p_t}{p_r}\right) \quad (1)$$

PL_{dB}: It is the attenuation of the wave in dB, p_t: It is the power transmitted, p_r: It is the power received.

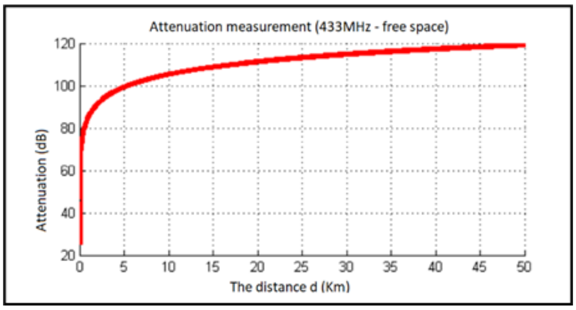

Figure 3. Radiofrequency waves - Attenuation of propagation

3.2. Method

In our study, We proposed an operating principle that is characterized by three complementary parts, the first part "See Block 1 Figure 4" is dedicated to the data processing it is represented by the ESP32 microcontroller as the main element in which we have added a module radio frequency transceiver to retrieve the data measured by the soil moisture sensors "see Block 2 Figure 4", moreover this part is responsible for sending the commands if certain conditions on temperature or humidity are checked to activate the three solenoid valves, this operation, therefore, makes it possible to open the solenoid valves to start irrigating the field for a time T, "See Block 3 Figure 4", the irrigation operation is characterized by a duration T, it is the space-time sufficient to irrigate the totality of our field, the experience shows that 15 min is more than enough to accomplish this operation, in our case it is a fixed value that satisfies the irrigation conditions. The second part is the cloud which plays a very important and intermediary role between the "Farmer" administrator and the ESP32 web server, in our article we used the ThingSpeak cloud which is an open-source internet of things platform, by relying on the local area network (LAN) network or the internet, we can store the various quantities coming from the processing unit via hypertext transfer protocol (HTTP) [16], these quantities will be analyzed and represented by curves to facilitate comparisons. Finally, the third part is reserved for the communication block using an approach based on an RF transmitter module "see Block 2" and another module for the RF receiver "see Block 3" [17], [18]. Figure 4 accurately illustrates the final main diagram provided in our smart irrigation system.

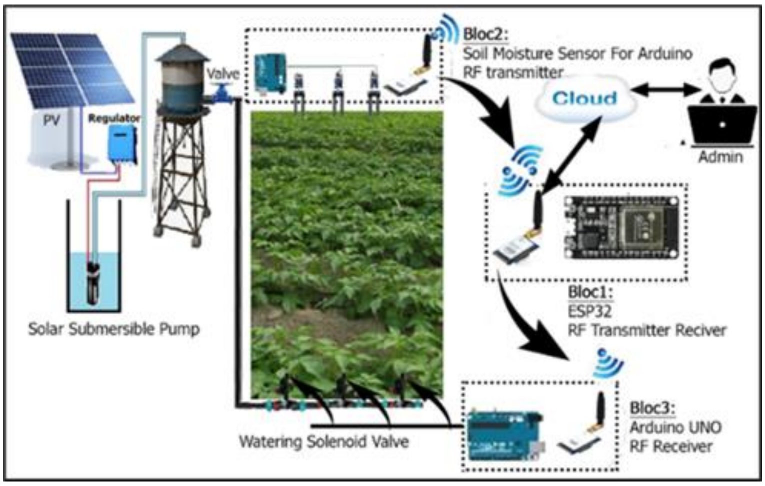

Figure 4. The main schematic diagrams

In this part, we will create a web server using the ESP32 microcontroller, on a dynamic web interface developed using hypertext markup language (HTML)5, to represent the values of all the previously measured monitoring parameters in real-time [19]-[21]. To ensure the WiFi connection and to properly implement this web server, we need the three main libraries, WiFi.h is required to use all WiFi related features, such as connecting access points, WiFiClient.h is required to send the request to the web browser, and Finally, WebServer.h to handle all HTTP protocols [22], [23]. Then we set the service set identifier (SSID) and the WiFi router password, in our case the SSID is "zaidan_iosm". Figure 5 shows a connection test [24], [25].

To start the webserver, we used the function server.begin () and when the client requests a web page by entering the IP address of the ESP32, the data to be sent is managed by the subroutine defined in server.on ("/", handleRoot), In the main loop, we handled the client's request with server.handleClient (), this subroutine is called when we validate an internet protocol (IP) address in a web browser to send data from ESP32 to the web browser [26], [27].

Figure 5. WIFI connection test

4. RESULTS AND DISCUSSION

In this study, Moisture levels are measured in two separate environments using a soil moisture sensor. The two measurements are taken at depths of 3.5 cm and 7 cm respectively, "see Figure 6", while the duration of this study is 31 days. Using this technique allows us to accumulate various humidity measurements. The method employed facilitates the collection of a range of humidity data.

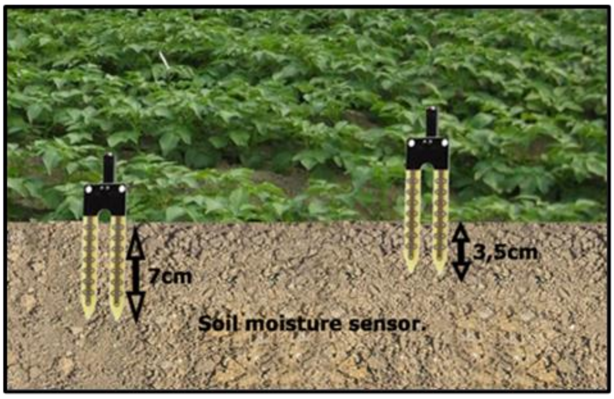

Figure 6. Soil moisture sensor implanted at a depth of 3.5 cm and 7 cm

The graphical representation of the data in Figure 7, Figure 8, and Figure 9 clearly shows the value of the wilting point related to soil moisture 45% [28], [29], according to the data related to the parsley plant «the case in our field», experience shows that the minimum moisture value to start new irrigation is very close to 45%. “Soil moisture threshold”, when the humidity value drops beyond the previously set threshold, leads to an automatic triggering of the solenoid valves for a period of 15 min, to start the self-irrigation of the plants. In our study, we targeted “Coriander” parsley, a species of plant in the opiate family. It is an aromatic plant characterized by a depth of roots between 2 cm and 7 cm, this depth interval is mainly removed at the depth of the holes to sow the parsley grains «practically between 1 cm and 2 cm». Our experience shows that when the root of parsley is at a depth close to 7 cm, the soil retains water for a greater period compared to the situation where the roots of parsley are at 3.5 cm. From the analysis of the representative graphs " Figure 7, Figure 8, and Figure 9." we noticed, that the plants whose roots are deeper in the soil "7 cm" are much more resistant to drought because the automatic irrigation is triggered 3 times in 31 days "see Figure 7". While plants with a root depth of 3.5 cm require a large amount of water, the solenoid valves are triggered 6 times in 31 days "see Figure 8". Note that, in our study, we set the threshold humidity value for the two environments and with the two depths 7 cm and 3.5 cm at 45%.

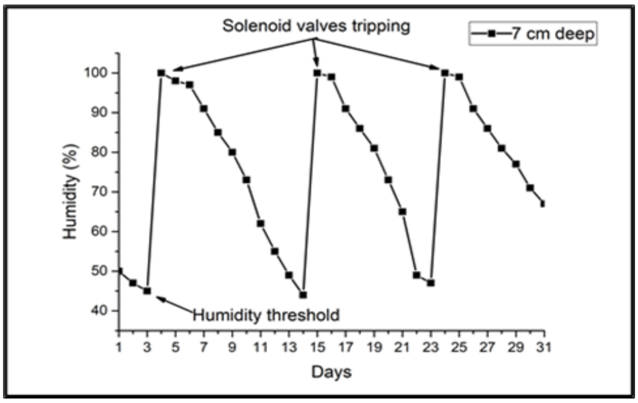

Figure 7. Humidity variation with a depth of 7 cm

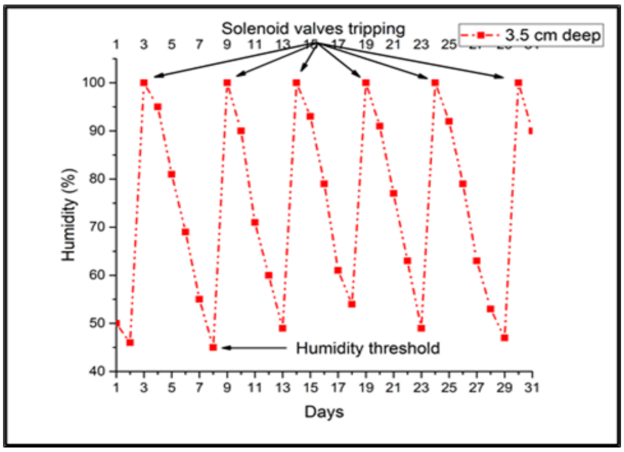

Figure 8. Humidity variation with a depth of 3.5 cm

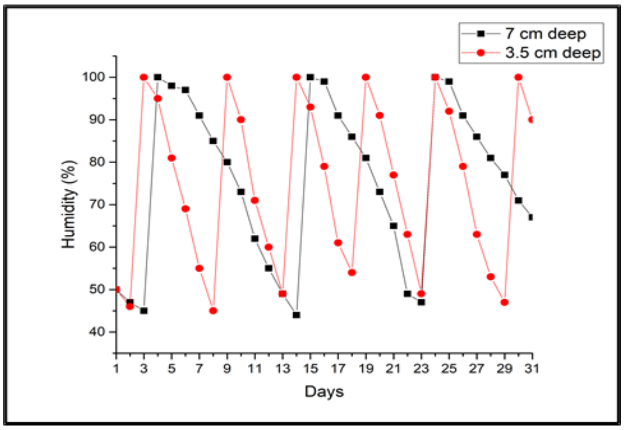

Figure 9. Humidity variation with the two depths 3.5 cm and 7 cm

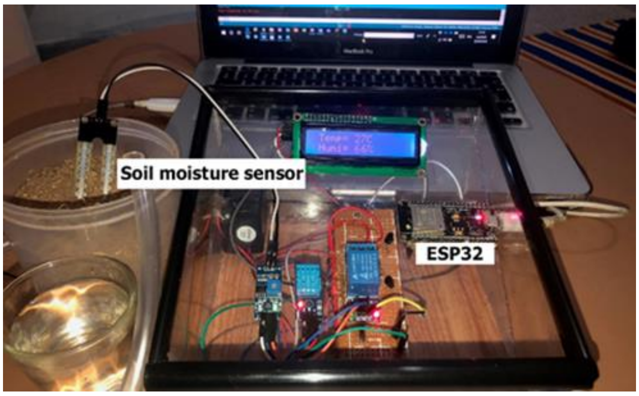

Figure 10. ESP32 microcontroller and soil moisture sensor

Figure 10 shows the ESP32 microcontroller and soil moisture sensor, while, in Figure 11, we have taken a very good look at the real-time humidity and temperature variation on the ThingSpeak platform linked to our server on ESP32 with a humidity sensor depth of 3.5 cm. In the same way, in Figure 12 and Figure 13, we observed and verified the same quantities on a dynamic Web interface on PC and on smartphones which shows that the solenoid valves are well synchronized with the displayed values while respecting the same threshold of humidity 45%

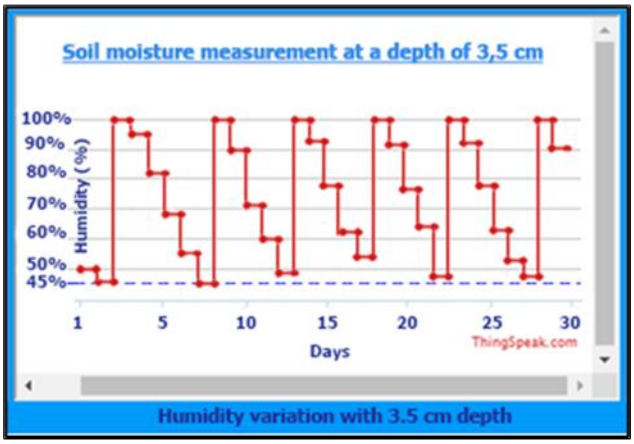

Figure 11. Humidity and temperature variation on the ThingSpeak platform

Figure 12. Variation of humidity and temperature on a dynamic web interface

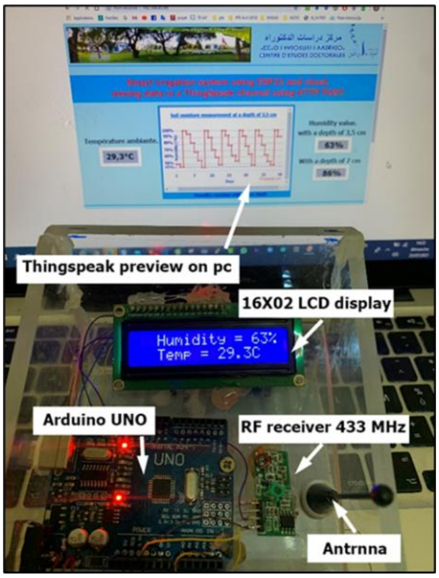

Figure 13. Overview

5. CONCLUSION

In this experimental study, we have studied an innovative method, which integrates several concepts based on the Internet of Things. To manage irrigation to efficiently operate a solar energy pump, in this study, we have very well benefited from the advantages of radiofrequency modules as the main element of communication in our field, so we used a web server based on an ESP32 microcontroller, and finally, we effectively exploited the ThingSpeak platform to observe in real-time the variations of the main quantities, humidity, and temperature. In comparison with other studies which aim at the same objectives, our study was implemented and tested, we estimated that our realization can retain an ideal soil moisture value in our garden with small consumption of water and energy. Our production is much more stable with simple maintenance and very easy to set up.

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BIOGRAPHIES OF AUTHORS

Zaidan Didi is a Ph.D. student researcher, Iot, Computer science research laboratory (LaRI), Faculty of Sciences, Ibn Tofail University, Kénitra. Professor at the Laayoune Higher School of Technology, Ibn Zohr University, Morocco, my research interests Iot, connected objects, digital electronics, Linux administration, and computer networks. He can be contacted at email: zaidan.didi@uit.ac.ma.

Ikram El Azami is a Professor Ph.D. at the Department of informatics, Université Ibn Tofail, Kenitra, Morocco, Ikram does research in Databases, Machine learning, Data Mining and Distributed Computing. Their most recent publication is 'X-ETL: A new method for designing multidimensional models'. He can be contacted at email: ikram.elazami@uit.ac.ma.