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Development of An Intelligent IoT Based Soil Monitoring And Irrigation System

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Abstract

In order for plants to thrive and have quality and increased yield, they need to be closely monitored while providing them with sufficient water supply; This need could be met by either rainfall or irrigation. In areas of little rainfall, full scale irrigation practices are employed, but some of these irrigation methods are not very efficient thus causing farmers to lose about 50% of water supplied. Therefore, this research is aimed at evaluating environmental parameters such as soil moisture, temperature and humidity while using the acquired data to develop an effective intelligent IoT based automated soil monitoring and irrigation system. These data are saved to the IoT ThingSpeak platform so that they can be used to analyzed past conditions plants thrived in to predict a future plant performance. This project was actualized using the NodeMCUESP8266 microcontroller, a DHT 11 sensor, a soil moisture sensor and a 5v water pump which was switched using a single channel 5v relay module. The results obtained shows that an intelligent IoT based automated soil monitoring and irrigation system could be designed and implemented to optimize crop performance and manage and control irrigation systems.

Keywords: *IoT, Thingspeak, NodeMCU, DHT 11, Soil Moisture*

1.0 INTRODUCTION

Irrigation is the artificial application of water to the soil or plant in the required quantity and at a specific time needed. Irrigation is thus a risk management tool for agricultural crop production and it helps in reducing the risk of crop yield due to drought because moisture can be added to the soil to meet the water requirements of the crop (Boaye & Frank, 2009). For plants and crops to thrive and be much more productive, not only do they need to be monitored but require water. This need is either met by rainfall or by irrigation. Areas with rainfall less than 250-300mm per season require full irrigation to grow crops. However, the efficiency of some irrigation method is relatively low and this causes farmers to lose 50% of the water supplied to the field due to deep percolation and runoff (Balasubramanian, 2018). The art of irrigation can be achieved using watering cans, sprinklers, emitters, surface systems characterized by the mode of transport of the water onto the point of application (Keller & Bliesner, 1990). Development of irrigation agriculture has become one of the most reliable strategies of increasing world food supply in order to meet the ever increasing global population of human beings (Nwa, Usoh, Okokon, Nta, & Etim, 2017). Environmental parameters such as soil moisture content, temperature, humidity, ph., radiation and a host of other factors plays a vital role in development of plants. Ogunti et al cited in (Ogunti, 2019)

However, application of technology like artificial intelligence and IoT in agriculture could have the greatest impact especially in developing countries where there is infrastructure such as electricity and wired transmission lines. The availability of this infrastructure and the internet can be used to overcome deficiencies in agriculture (Ogunti, 2019).

IoT devices are expected to have a significant impact on farming while meeting the increasing consumption need of the global population which is expected to increase to 70% by 2050 (Abbas et al., 2018).

"Traditional methods of irrigation such as overhead sprinkler is not much efficient as it leads to water wastage and promote disease such as fungus formation due to excess soil moisture"(Dcunha, 2019).

Sowmiya and Sivaranjani (2017) reported that smart agriculture will play a very vital role in promoting cultivation. They suggested that a solution can be gotten by placing sensors in the cultivation land to monitor and measure the soil efficiency.

Therefore, for an increased soil quality, crop production and efficient soil irrigation, a means to maintaining these parameters must be developed. Development of Intelligent IoT based soil monitoring and irrigation system not only solves this problem, but also helps get and store data that can be analyzed and used by farmers to predict crop production yield in future times. Also the design of a system to control irrigation pump using Fuzzy logic control and the NodeMCUESP8266.

2.0 DESIGN METHODOLOGY

2.1 Proposed System

The system Intelligent IoT based soil monitoring and irrigation system is designed to ease operation on the farm land by optimizing the rate of water use and conservation. This system was actualized using a host of components, software and the Fuzzy logic control which is used mainly for the irrigation control.

2.2 Hardware and Software Components.

A combination of hardware and software components were used actualize this project. Some of the hardware includes

- NodeMCUesp8266.
- 5v Relay module.
- Moisture Sensor.
- Temperature and Humidity Sensor (DHT11).
- 5v mini DC pump.
- 5v Relay module.

The software requirement of this project design includes:

- Thingspeak API.
- Arduino IDE.
- MATLAB

2.3 System Architecture

The sensors are connected a the NodeMCUesp8266 microcontroller as shown in the block diagram below. This NodeMCU controller was selected because is it an integrated Wi-Fi module and its ease of use with a wide range of sensors. Readings from the field sensors are processed by the controller which employs fuzzy logic control to implement intelligent irrigation.

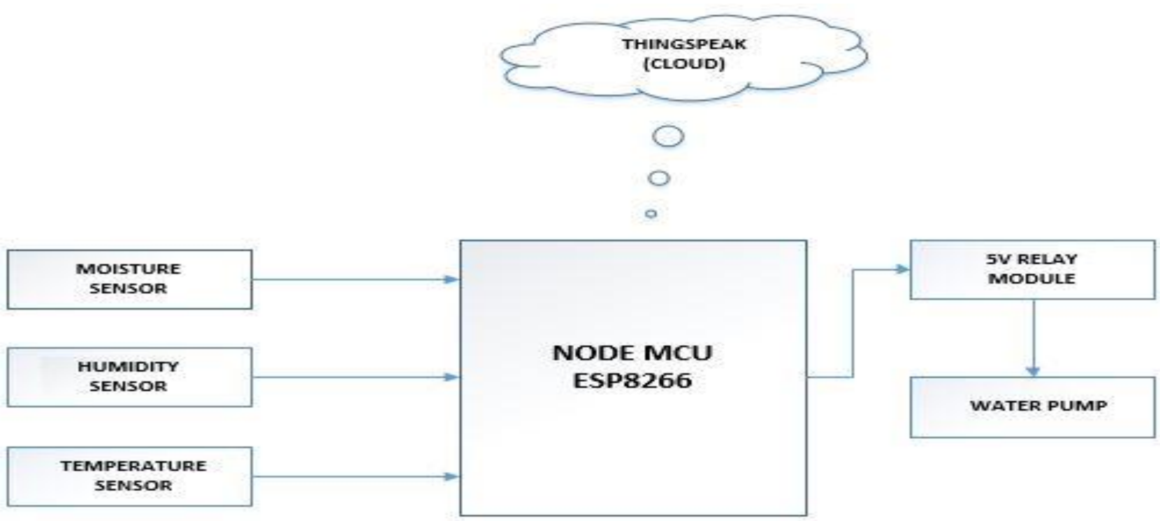


Figure 1: functional block diagram

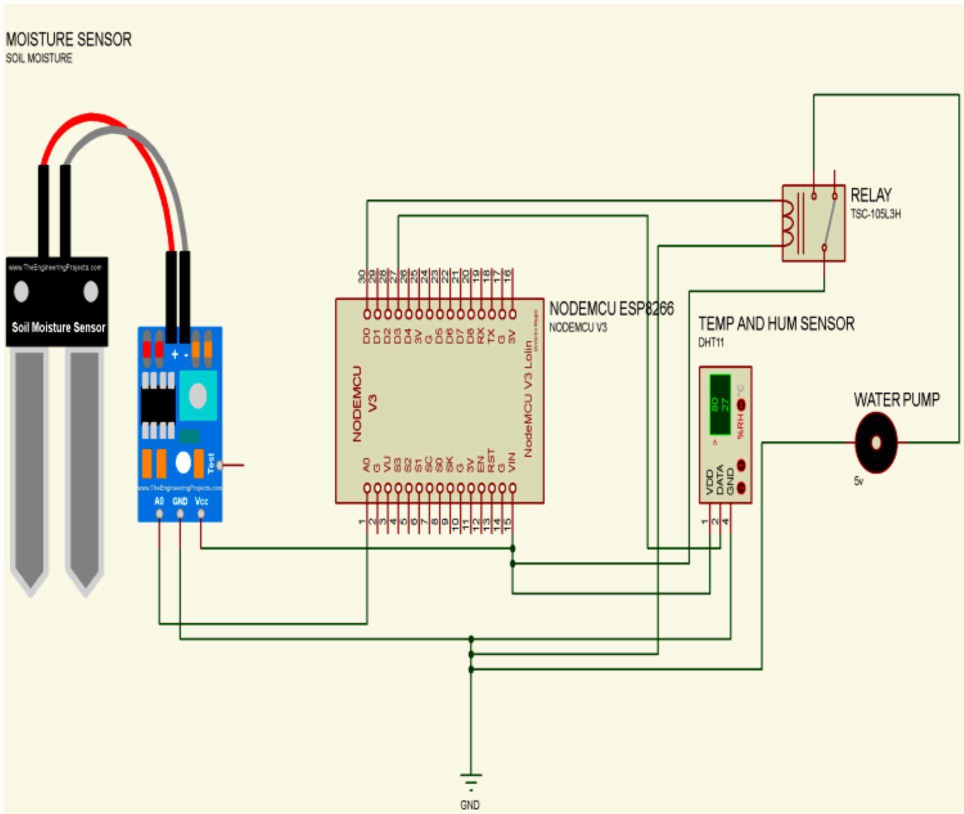


Figure 2: circuit diagram

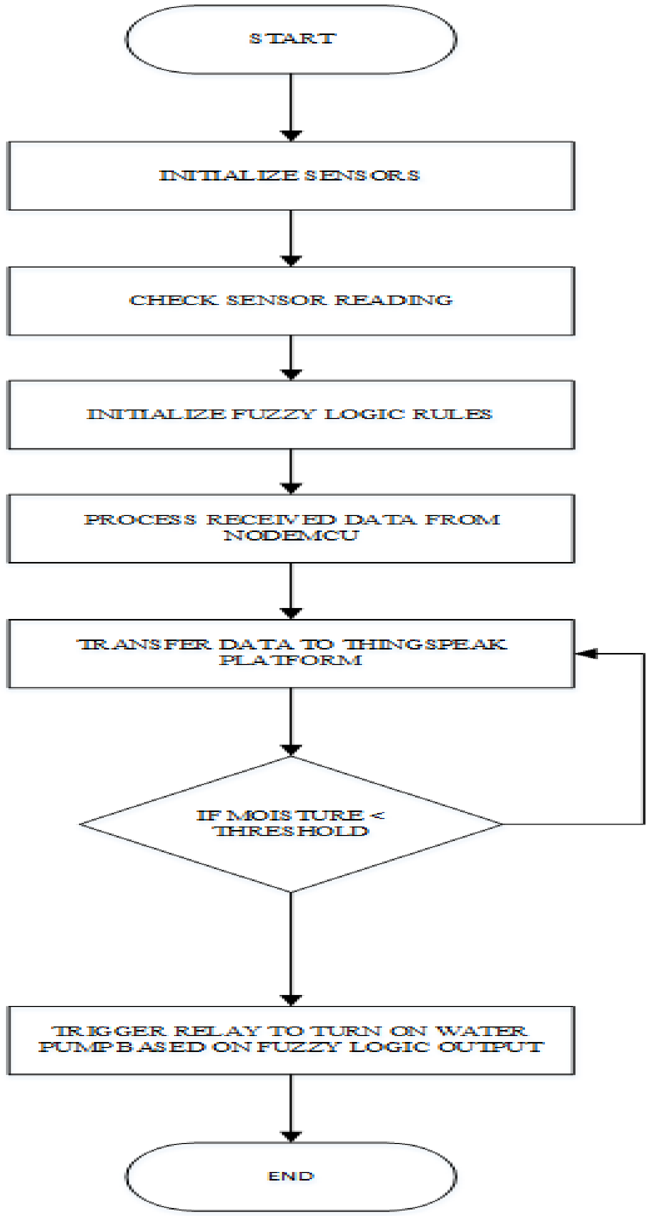


Figure 3: Flowchart

2.4 Component Description

NodemcuEsp8266

According to Singh *et al* (2019), ESP8266 is a complete and self-contained Wi-Fi network solution that can carry software application, or through another application processor uninstall all Wi-Fi networking capabilities. When the device is mounted and as the only application of the application processor, the flash memory can be started directly from an external Move. Built-in cache memory will help improve system performance and reduce memory requirements. Another situation is when wireless Internet access the task of Wi-Fi adapter, you can add it to any microcontroller-based design, and the connection is simple, just by SPI / SDIO interface or central processor AHB bridge interface. Processing and storage capacity on ESP8266 powerful piece, it can be integrated via GPIO ports sensors and other applications specific equipment to achieve the lowest early in the development and operation of at least occupy system resources.

Figure 4: NodeMCUESP8266

Soil Moisture Sensor

This type of sensors measures the water content in soil based on the volume present in it at a time. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can therefore be used by farmers or gardeners. (Shomefun, Awosope, & Ebenezer, 2018)

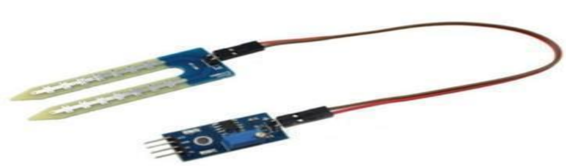


Figure 5: Soil Moisture Sensor

DHT 11

DHT11 sensor is used for measuring temperature and humidity. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air. This sensor is cost effective, provides low power consumption and up-to 20-meter signal transmission is possible.

SPECIFICATION

- Supply Voltage: +5 V
- Temperature range :0-50 °C error of ± 2 °C
- Humidity :20-90% RH ± 5% RH error

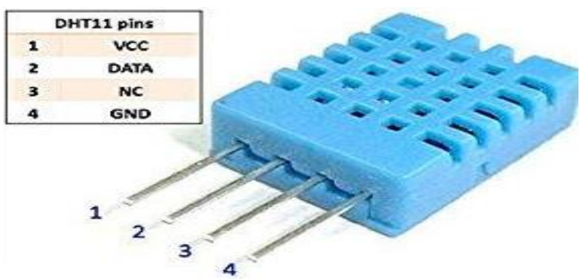


Figure 6: Humidity and Temperature sensor (DHT11)

5v DC mini Pump
Small DC Submersible water pumps push fluid to the surface as opposed to jet pumps having to pull fluids. Submersibles are more efficient than jet pumps. It is usually operated between 3v to 12v.

- Voltage: 2.5-10V 2.
- Maximum lift: 40-110cm / 15.75"-43.4" 3.
- Flow rate: 80-120L/H 4.
- Outside diameter: 7.5mm / 0.3"

Figure 7: 5v Dc Pump

5v Relay Module

The relay module is an electrically operated switch that allows you to turn on or off a circuit using voltage and/or current much higher than a microcontroller could handle

Figure 8: 5V relay module

2.5 Fuzzy Inference system

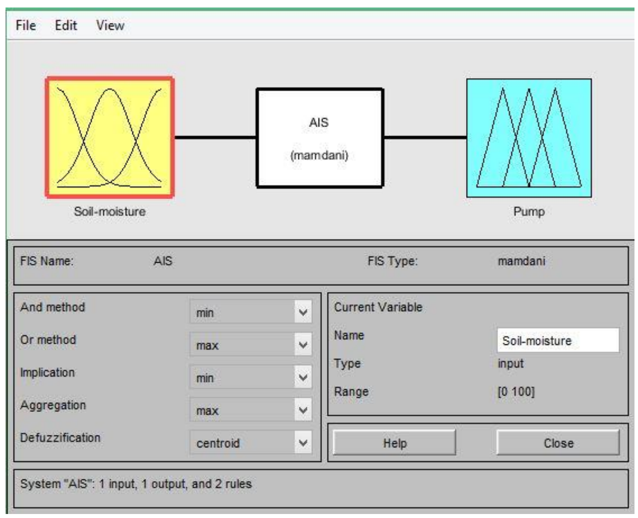


Figure 9: Fuzzy inference System GUI editor

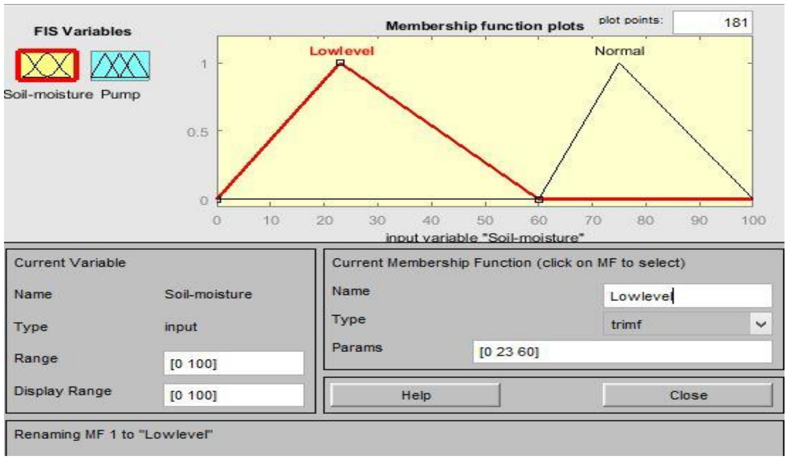
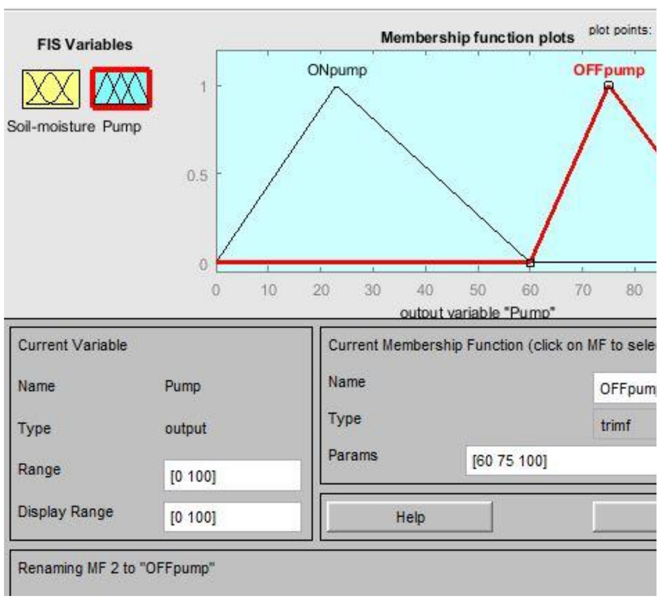


Figure 10: Fuzzy Input Membership Function (Soil moisture Level)



3.0. RESULTS AND DISCUSION

Before examining the details of a fuzzy system, possible range of input and output values must be identified. A triangular membership function was used to implement the mamdani method. There are just two input membership function as shown in Figure 10. These represent the soil moisture level and are labelled as low level and normal. The output membership function represents the pump control for the irrigation. The output membership function as shown in Figure. 11 are labelled as ON pump and OFF pump. The same triangular shaped membership functions were used for both input and output. The rule viewers as shown in Figure 13 and Figure 14, shows the simulated pump control status based on a soil moisture level.

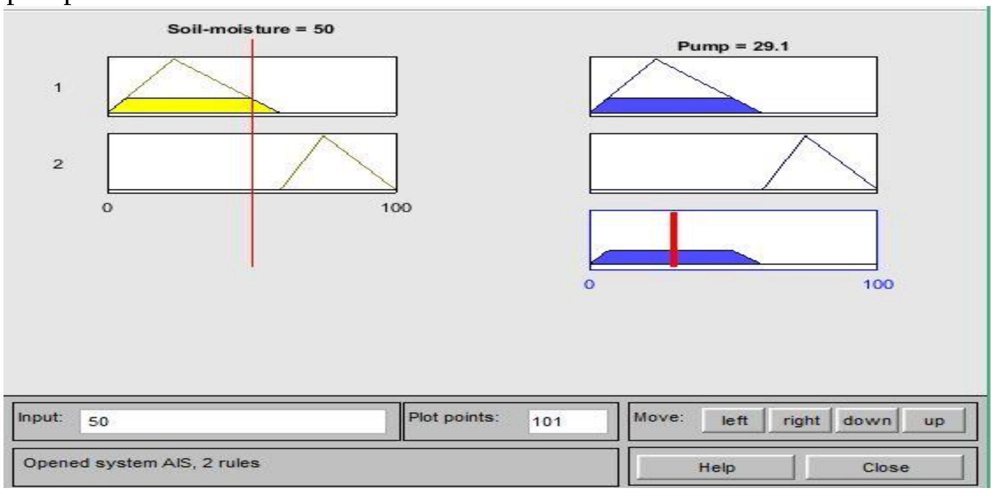


Figure 13: MATLAB Rule viewer for Output 1

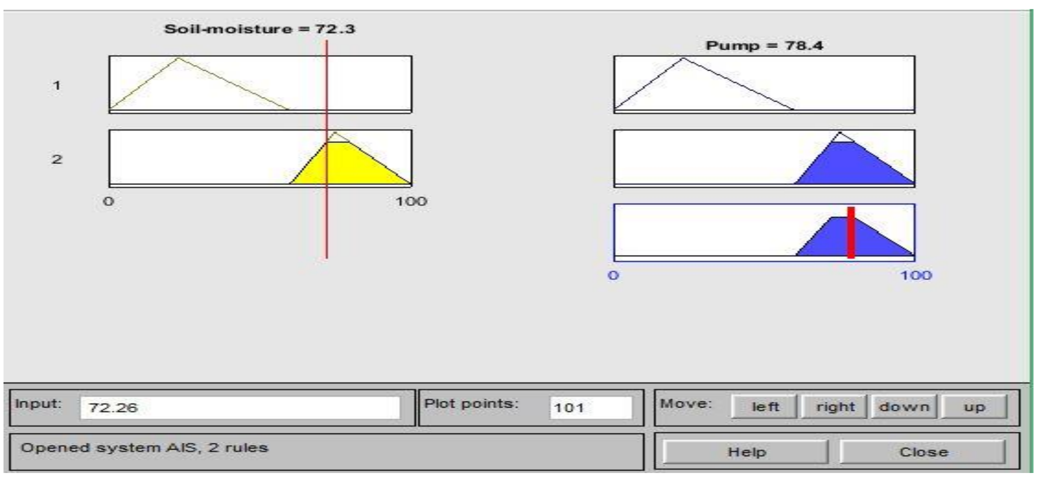


Figure 14: MATLAB Rule Viewer Output 2

The relationship between the input and output variables can be easily visualized from Figure 15 and Figure 16 which is a surface generated to analyze the performance of the system.

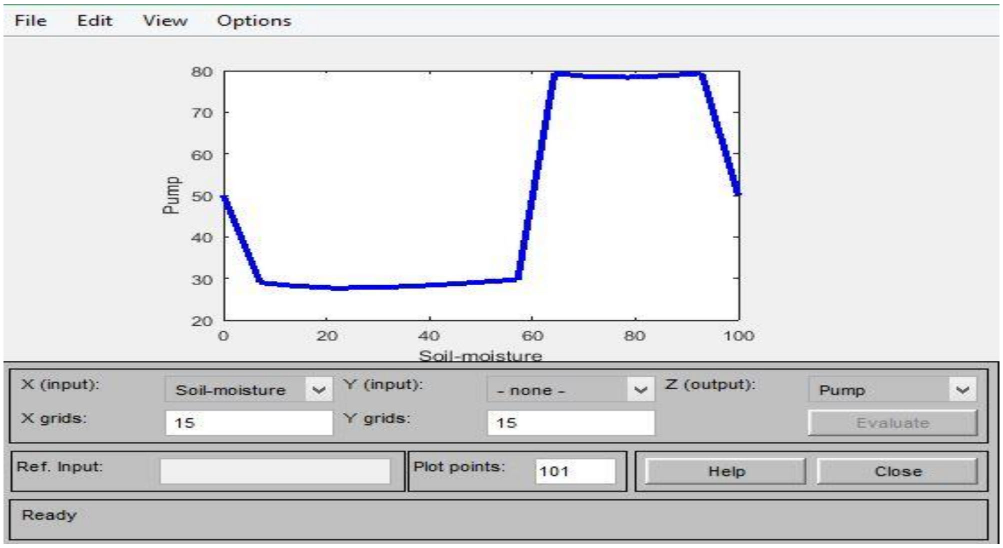


Figure 15: Surface Viewer

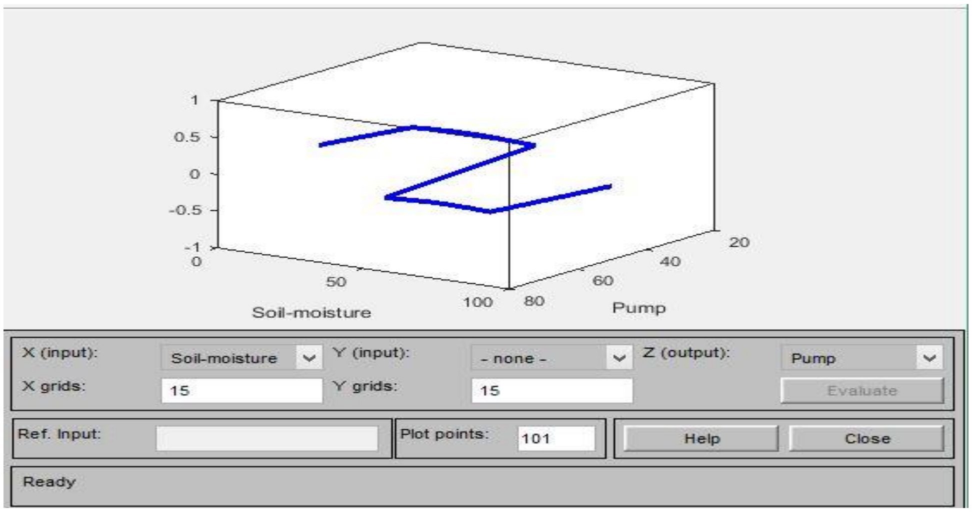


Figure 16: Surface Viewer 3D

3.1 Thingspeak results

The results of the data gotten from the DHT11 sensor and the soil moisture level are captured in Fig.17 and Fig.18. these data was acquired on the first Day of testing the model's performance, this test lasted for about 2hours.

Figure 17: soil moisture and Temperature results Day 1

Figure 18: Humidity and pump Status Day 1

Further performance test was carried on the model and this also lasted for two hours, this showed good working condition of the system and is as shown in Figure 19, Figure 20, Figure 21 and Figure 22.

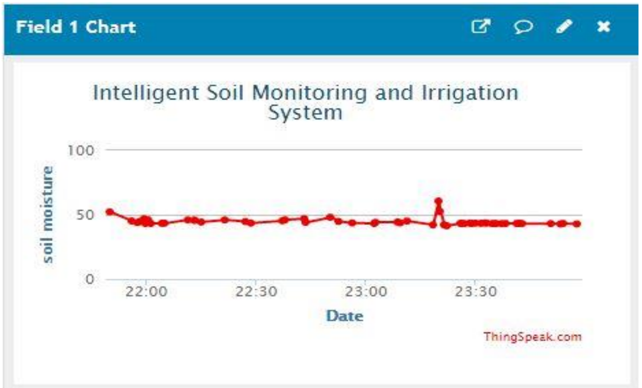


Figure 19: Soil moisture Reading Day 2

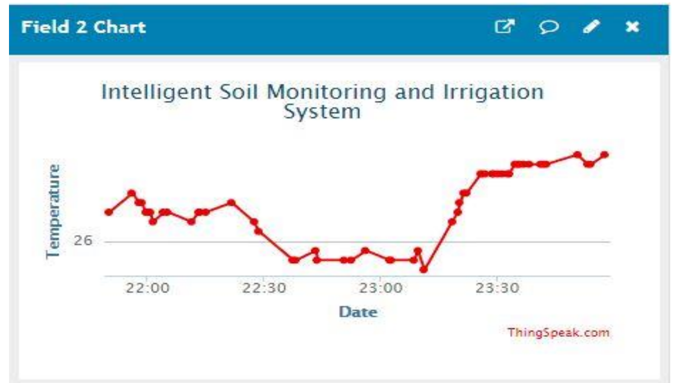


Figure 20: Temperature Reading Day 2

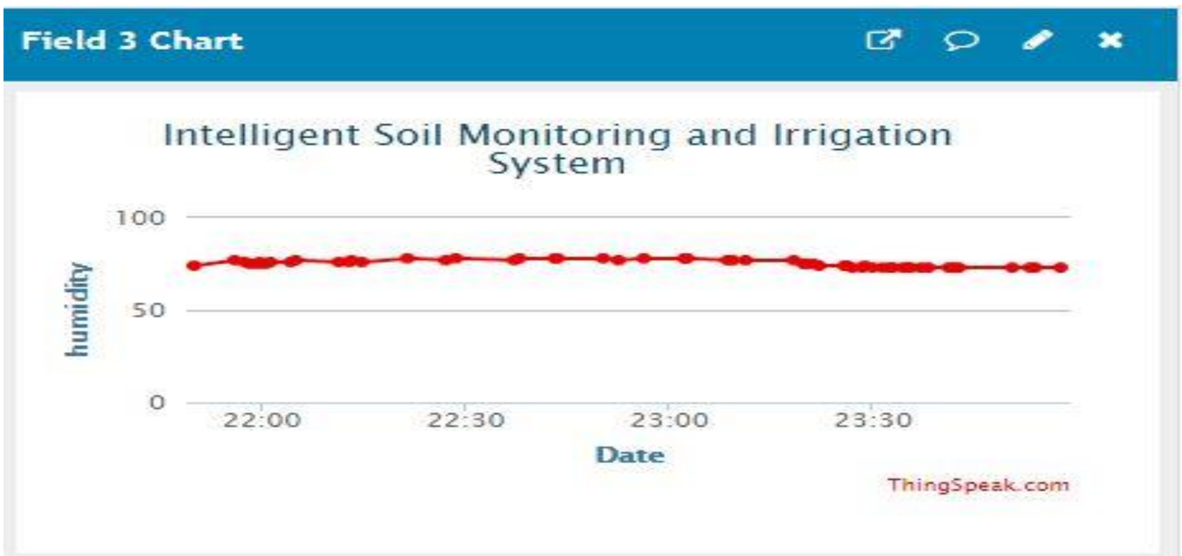


Figure 21: Humidity Reading Day 2.

4.0 Conclusion

In order to reduce the need for human intervention in farming, agricultural monitoring is necessary. This research is aimed at educating famers on the ways technological application can be used to monitor and control processes. The actualization of this system will lead to smart water management system on the farm there by optimizing already existing irrigation processes. The data acquired are stored on the IoT platform for future analyzes and performance prediction of the farm land. However, for future advancements of this system, different kinds of sensors such as pH sensors, Carbon dioxide Sensors and light Sensors could be Installed thereby providing enough reference data for analysis. Also, more than one input variable can be used in the Fuzzy System to obtain a more robust system.

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