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Development of Smart Irrigation System with Integrated GSM and Wifi Control

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ABSTRACT: A functional smart irrigation system with integrated GSM and Wi-Fi features that enables the farmer to remotely check soil moisture status as well as turn on and turn off the irrigation pump remotely, where necessary had been developed in this study. The system consists of a DC pump, a GSM module, moisture sensor, and the NodeMCU microcontroller. The prototype is essentially a mix of hardware module and software program and made up of several subunits. It behaves functions intelligently as a switching system being able to detect the moisture content level of the soil and then automatically irrigate the crop where the conditions are necessary. The motor is automatically turned ON or OFF in accordance with the soil moisture content level. The readings of the soil sensor are sent to a processing unit which generates graphs for analysis thereby helping the farmer make informed decisions.

1.0 INTRODUCTION

The ever-increasing world population and the relative requirement to produce more food via sustainable agricultural practices have over the years made it imperative to leverage recent advances in science and technology to improve agricultural practices. Although agriculture is practiced in most parts of the world, there is still a relative shortage of food due to several natural and man-made factors. The lack of widespread irrigation especially in developing countries of the world has been identified as one of the challenges of producing in these regions of the world (Hussain et al. 2001). Olaniran and Ojo (2019), noted that an increase in the production of food production through efficient irrigation will reduce poverty, generate several direct and indirect employment opportunities and consequently increase the GDP of the country. According to Olaniran and Ojo (2019), Nigeria has enough water resources to support sustainable irrigation practices. The country is adjudged to have about 3 million hectares estimated irrigation potential. This represents about 10% of the estimated 30 million hectares that are cultivated each year.

Adequate irrigation has been identified as one of the effective ways towards improving crop yield and consequently food security as such there is a need for innovative solutions aimed at improving irrigation in Nigeria and other developing countries of the world with relatively low irrigation practices. According to Youssef et al (2022), the last 60 years have been characterized by the remarkable development of water resources for agricultural purposes due to the increased population growth and consequently increased demand for food. According to Easy-Irrigation (2022), the earliest forms of irrigation surfaced around 8000 years ago as the need to feed the growing population increased. Sojka et al. (2002), noted that irrigation sprang up more or less independently across the Asian continents and different parts of the world and the level of complexity of each irrigation system varied from one place to the other and was largely dependent on the understanding of both large- and small-scale hydraulic principles by the local populace.

Irrigation essentially entails an artificial supply of water to the soil to ensure the presence of adequate moisture in the soil and mitigate against the incidences of drought and other natural and artificial challenges. The significance of irrigation to the development of agriculture cannot be over-emphasized as it ensures there is adequate moisture in the soil to facilitate the proper growth of crops. The conventional means of irrigating farms and gardens is time-consuming, demanding and might not be feasible in some cases. To overcome this rather saddening situation, advances in science and technology have been leveraged by researchers and farmers over the years to create a functional smart irrigation system for domestic and commercial purposes. `

Water availability in adequate quantity is one of the most important metrics that determines healthy plant growth. Excess water or scarcity of water can hinder plant growth hence efforts are usually made to ensure plants are supplied with just the amount of water they need per time. Irrigation of plants has numerous advantages including improved growth of crops, landscapes maintenance and revegetation of soils in dry regions and through periods where precipitation is less than average. Conventional methods of irrigation includes manual labor, irrigating the fields using sprinklers, furrow irrigation, drip irrigation etc. According to (Ighrakpata et al., 2019), high pressure sprinklers also called rotors are driven by a ball drive, gear drive or impact mechanism. The conventional irrigation system is based on manual observation of the weather and soil condition in real-time as such a water schedule is driven by the knowledge and experience of the farmer, which is prone to errors and assumptions. This could lead to the supply of too much or too little water to the crop resulting in unintentional flooding/wastage of water or the availability of too little water for crop growth. Hence, there exists the need to develop a smart irrigation system that can accurately measure the moisture content level of the soil and supply adequate quantity of water to the plants. Also, the need for the farmer to remotely monitor the irrigation process from any location is apparent.

2.0 REVIEW OF PAST WORK

Smart irrigation systems essentially leverage on the functionality of moisture sensors to detect the water level and send corresponding information to the microcontroller which turns on the water pump based on preset levels. Over the years several variants of smart irrigation systems have been developed. Syaza et al. (2018) worked on a smart home garden with an automated irrigation system. The developed system leveraged the Raspberry pi, a solenoid valve as well as a soil moisture sensor having capacity to detect the moisture content level in the soil and automate the irrigation process. Karthikeyan et al. (2019), worked on a suitable smart irrigation prototype using a moisture sensor, the DHT 11 temperature and the relative humidity sensor. In a similar research, Sharmin et. al (2018), developed an Arduino-based smart irrigation system consisting of the Arduino Uno microcontroller, a mini pump, a moisture sensor and a relay. The developed prototype was programmed to turn on the water pump when the water level falls below a preset point. Barbade et. al. (2021) implemented an Arduino-based sprinkler system for irrigating the farmland. The hardware includes the moisture sensor, Arduino board, relay module and water pump. All required parts were connected to the Atmega 328. The moisture level is sensed by the soil sensor and the data is transferred to the Arduino board to determine the next process. The system functions such that the pump is turned on if the soil water level is below a preset value. If the moisture level is below a pre-set value, the Arduino UNO board sends a signal to the relay module to turn on the water pump to water the plant. Once the soil water level reaches a value indicative of sufficient water in the soil, the relay turns off the water pump automatically. Rafique et al., (2021) developed a prototype smart irrigation and water management system for conventional farming. The system used a soil moisture sensor for assessing the quantity of moisture in the soil. Over the years, different researchers have worked on a plethora of smart irrigation systems with diverse functionalities. These systems essentially consist of a sensor, a microcontroller and a suitable pump as their core components. This study seeks to develop a functional smart irrigation system with integrated GSM and Wi-Fi features that enables the farmer to remotely check soil moisture status as well as turn on and off the irrigation pump remotely, where necessary.

3.0 MATERIALS AND METHODS

The developed smart irrigation system prototype essentially demonstrates the concept of IoT based smart irrigation techniques and entails the use of appropriate sensors to obtain the moisture level of soil so as to automate the irrigation process. The system consists of a DC pump, a GSM module, moisture sensor, and the NodeMCU microcontroller. The consideration made in the development of the smart irrigation prototype includes:

Efficiency: The device must be efficient and able to demonstrate the application of IoT techniques in optimizing the irrigation process.

Portability and Ease of Usage: The prototype was designed to be portable and easy to use and maintain

The prototype is essentially a mix of hardware module and software. The system was developed using embedded C via the Arduino IDE or Arduino Software. Proteus' electronics and simulation tool was effectively used to create the schematic designs for the developed system. The Arduino IDE (Integrated Development Environment) has a series of menus and a text editor used to write codes. It also has a text console and a message area. Another important feature of the IDE is a toolbar having buttons which are used for common functions. The IDE connects the Arduino hardware to enable program uploads and further communicate with the uploaded programs. The system is made up of several subunits as discussed in the following sections.

3.1 Soil Moisture Monitoring Unit

This unit deals with the usage of suitable sensors in monitoring and measuring the amount of moisture of the soil. The fork shaped moisture sensor was used in this study. The fork-shaped probe has two exposed conductors. The probe acts as a variable resistor. The resistance of the probe varies in accordance with the water content in the soil. In the working mode, the system is programmed to check the soil moisture content specifically to ascertain the need to water the soil based on some preset moisture level of the moisture sensor. The moisture sensor senses the level of soil moisture and feeds the processing unit with corresponding signals. The fork shaped moisture sensor has the following parameters as shown in Table 1.

Table 1. Moisture Sensor Specifications and features

Parameter	Value
Voltage of operation:	3.3V to 5V DC
Current at which it operates:	15mA
Digital Output	0V-5V
Analog Output	0V to 5V

3.2 Processing Unit

The processing unit essentially accepts inputs from moisture sensors and controls the outputs based on preprogrammed directions. The processing unit is made up of the NodeMCU Wi-Fi Module, the GSM Module and the relay module. The NodeMcu is an open-source development board and firmware. It is depends on ESP8266-12E Wi-Fi module. The user is allowed to program ESP8266 Wi-Fi module with Arduino IDE or with LUA programming language. The NodeMcu Dev board allows flashing directly from the USB port. Features of WIFI access point, station and microcontroller are combined in it. This makes it u very useful Wi-Fi networking tool. It can be put to use either as an access point as a station or as a host. Key specifications and features of NodeMCU ESP8266 are presented as follows:

S/N	PARAMETER	DESCRIPTION/VALUE
1	Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
2	Voltage of operation	3.3V
3	Voltage specification for input	7-12V

At the heart of the Node mcu Wi-Fi module is a SIM800L GSM cellular chip from SimCom. SIM800L GSM chip is operated using a voltage range of 3.4V - 4.4V. This makes it an very suitable for direct LiPo battery supply. The module has a full modem serial port, two microphone inputs and speaker output, a SIM card interface, sleep modewith0.7mA and support frequency modulation and pulse width modulation.

The SIM800L GSM chip data pins (including pins for communicating with the microcontroller over UART) are broken out to 0.1″ pitch headers. The module has auto baud detection and it supports baud rate from 1200bps to 115200 bps. To connect to a network, the module needs an external antenna. It usually comes with a Helical Antenna which solders directly to the NET pin on PCB.

The Relay Module forms part of the processing unit. This essentially consists of a relay for controlling the DC pump. The relay is triggered by the microcontroller which then turns on or off the pump depending on the desired action.

3.3 The Output Unit

The output unit comprises primarily of the submersible DC Pump. The pump can be operated with a power supply with voltage level ranging from a 2.5 to 6V. The pump can take up to 120 liters per hour. Its current consumption is low (approximately 220mA). A pipe is connected to the motor outlet after which the pump is submerged in water. Figure 1 shows the overall circuit diagram of the system. The system essentially communicates via the serial protocol and for the sim module. Thus, the corresponding transmits and receive pins are connected across the nodeMCU and GSM module. The input of the soil moisture level sensor, is connected to the analog inputs of the target NodeMCU IoT module. Figure 1 shows the circuit diagram of the smart irrigation system.

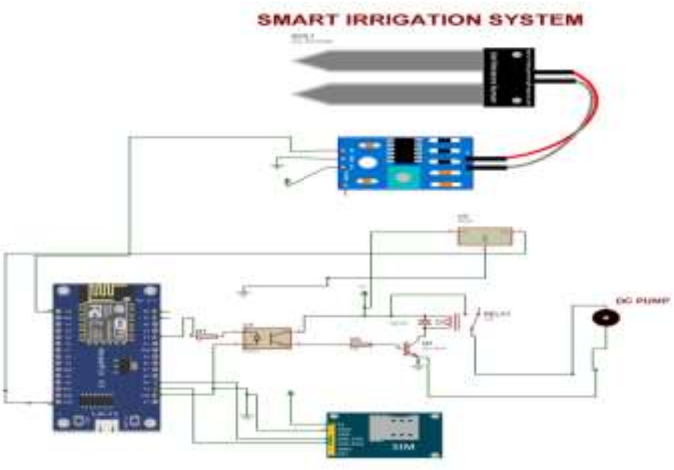

Figure 1: Circuit overview of smart irrigation system

The developed smart irrigation prototype was powered on by using the power adapter after switching on the GSM module and inserting a suitable Sim in the SIM port. The GSM module was allowed to initialize and register a network as indicated by the flashing of the indicator LED ever on the SIM800L GSM module. The integrated device Wi-Fi features allows for contact free control and monitoring of the moisture level via the device. The device integrated hotspots allow for any user within a 10m radius to access the device dashboard through the device security password.

On connection to device hotspot, via the device password, the remote dashboard was accessed via a choice browser by entering the host IP https://192.168.4.1 as illustrated in Figure 2.

Fig 2 Server Host IP address

The device provides a real time display of the moisture level via the integrated dashboard to enable the user monitor the status of the target farm / garden remotely as shown in Figure 3.

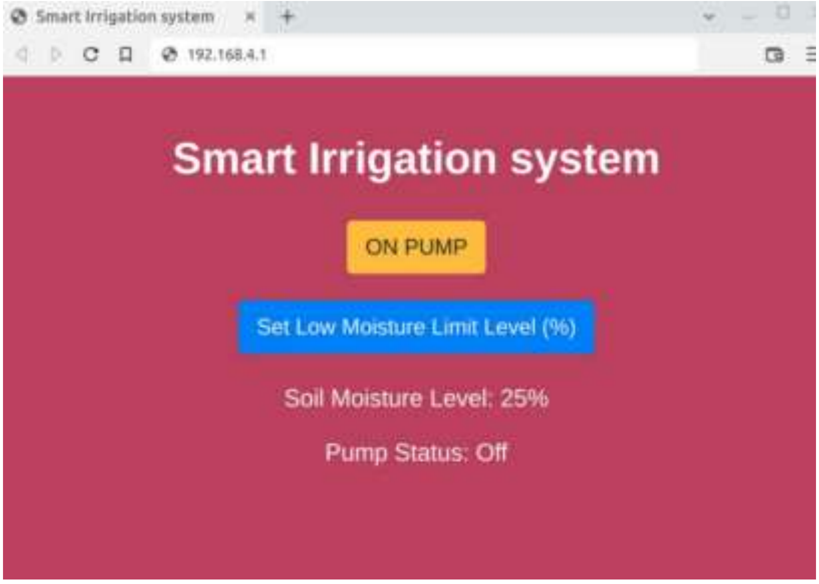

Figure 3: Real time display of moisture level

To ensure that the irrigated farm or garden get irrigated promptly, the device was programmed to allow the user set a low moisture level point at which the irrigation pump will automatically turn on as shown in Figure 4.

Figure 4: Moisture level setting

4.0 TESTS, RESULTS AND DISCUSSION

To test pump action when the moisture is below a preset level. The moisture sensor was place in a test sample of dry sand Result: on relatively dry sand, the moisture sensor indicated 0.0% on the dashboard and the pump was automatically turned on as the moisture level was below the preset level of 20%. Other test conditions were created by varying the level of water on the soil and the result obtained were indicated below

Table 2: Test results

S/N	Test condition	Moisture reading (%)	Pres-set Low Alert (%)	Pump Action
1	Dry soil	0.0	20	ON
2	Damp soil	38	20	OFF
3	Waterlogged Soil	66	20	OFF
4	Water Jar	79.07	20	OFF

The result obtained clearly showed the relative absence of moisture in dry soil samples and on switching on the system, the pump was automatically turned on whenever the current moisture level recorded was below the set low level point.

The integrated GSM module was designed to allow the user to turn the PUMP ON and OFF via a simple SMS to the phone number inserted in the module as outlined below.

Table 3: SMS Feature of the Pump

S/N	SMS CONTENT	Programmed response
1	pump on	Turn on pump
2	pump off	Turn off pump

When an SMS with the content "pump on" was sent to the device, the pump was turned on when the system received the SMS. The device was also programmed to generate a suitable response to the SMS sender as shown in Figure 5. The device was found to perform the desired operation when the preprogrammed keywords are sent via SMS

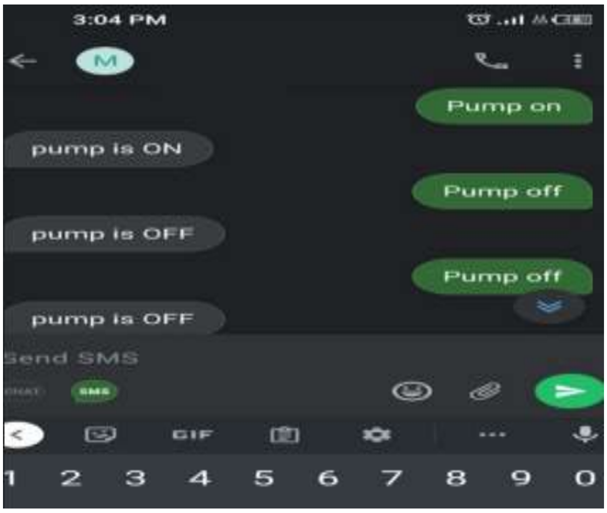

Figure 5: GUI response to the SMS sender

5.0 CONCLUSION AND RECOMMENDATION

Smart irrigation systems will undeniably improve the yield of crops while ensuring wastage of water is minimized thus reducing the overall cost of agriculture by the target user. The developed smart irrigation prototype helps to monitor and control the level of moisture in the soil via a moisture sensor and GSM module, water pump and the NodeMCU IoT module.

The develop prototype was duly tested and found to meet the project objective of monitoring the level of moisture in the soil as well as providing means of automatically turning off or on the water pump when the moisture level reaches a predetermined point.

The SMS feature of the device also allows for the user to control the device via an SMS with pre-programmed keywords as content.

Integration of additional sensor to provide more information and integration of GPRS module to allow for internet connection and more wide range control of devices regardless of location is recommended for further work.

CONFLICT OF INTEREST

We have no conflict of interest to declare.

REFERENCES

1. Youssef Ahansal, Mourad Bouziani, Reda Yaagoubi, Imane Sebari, Karima Sebari, Lahcen Kenny (2022). Towards Smart Irrigation: A Literature Review on the Use of Geospatial Technologies and Machine Learning in the Management of Water Resources in Arboriculture. Agronomy **2022**, 12, 297. https://doi.org/10.3390/agronomy12020297
2. Sharmin Akter, PinkiRani Mahanta, Maliha Haque Mim, Md Rakib Hasan, Raziun Uddin Ahmed, Md Mostasim Billah (2018). Developing a Smart Irrigation System Using Arduino. International Journal of Research Studies in Science, Engineering and Technology Volume 6, Issue 1, 2018, PP 31-39.
3. G M Barbade, Mahajan Vasudha, Pasarge Sanika, Shinde Sandhya (2021). Automatic Sprinkler System using Arduino. Indian Journal of Microprocessors and Microcontroller (IJMM), Volume-1 Issue-2, September 2021, pp.12–16.
4. Easy-Irrigation. (2022). A History of Agricultural Irrigation: Easy Irrigation, Watering and Irrigation. [online]. Available from: https://www.easy-irrigation.co.uk/a-history-of-agricultural-page-29?zenid=4rnc274sd3bge01sb46m6q1lo4 [Accessed August 17, 2022].
5. Hussain, I.; Yokoyama, K.; Hunzai, I. (2001). Irrigation against rural poverty: an overview of issues and pro-poor intervention strategies in irrigated agriculture in Asia. In Hussain, I.; Biltonen, E. (Eds.) Irrigation against rural poverty: an overview of issues and pro-poor intervention strategies in irrigated agriculture in Asia. Proceedings of National Workshops on Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia, Bangladesh, China, India, Indonesia, Pakistan and Vietnam, [9-10 August 2001, Colombo, Sri Lanka]: International Water Management Institute (IWMI). pp.x-xix..
6. Syaza norfilsha Ishak, Nik Noordini Nik Abd Malik, Nurul Muazzah Abdul Latiff, Ghazali N.Effiyana, Muhammad Ariff Baharudin (2017). Smart home garden irrigation system using Raspberry Pi., 2017 IEEE 13th Malaysia International Conference on Communications (MICC) pp.101–106.
7. Ighrakpata, U., Chouikha, M., Ejofodomi, Tega A., & Ofualagba, G. (2019). AUTOMATION OF IRRIGATION SYSTEMS AND DESIGN OF AUTOMATED IRRIGATION SYSTEMS. In *International Journal Water Resources Management and Irrigation Engineering Research* (Vol. 2, Issue 1).
8. Karthikeyan, R.A. et al. (2019). Smart irrigation systems using sensors and GSM. *International Journal of Recent Technology and Engineering*, 8(1), pp.884–886.
9. Olaniran, J. and Ojo, O.I. (2019). Assessment of Irrigation System on Crop Production and Farmers' Assessment of Irrigation System on Crop Production and Farmers' Economy in Lagos State , Nigeria. *International Journal of Engineering*, (June 2020), pp.175–184. [online]. Available from: https://www.proquest.com/docview.fulltext.hitnavigationswitch:setkeepsearchtermnavigationon/true;jsessionid=9BF2EC7F41F8EBE7EC1EC28DB6756E7B.i-09c53fca04ce9b224?t:ac=2344260073.
10. Rafique, M. A. Z. M., Tay, F. S., & Then, Y. L. (2021). Design and Development of Smart Irrigation and Water Management System for Conventional Farming. *Journal of Physics: Conference Series*, *1844*(1). https://doi.org/10.1088/1742-6596/1844/1/012009
11. Sojka R., Bjorneberg D. and Entry, J. (2002). Irrigation: Historical Perspective. *Encyclopedia of Soil Science, Third Edition*, (1), pp.1264–1268.