GSM-Controlled Irrigation System (GSMCIS) for Vegetable Farmers in Ghana*

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Abstract

The development of vegetable production in Ghana has largely been reliant on the drip system of irrigation. Presently, irrigation of vegetable farms in Anloga, a town in the Volta region of Ghana has been upgraded to the old tube well system. However, the drip system of irrigation still needs constant vigilance, which is a real problem for farmers who have their farmlands scattered at several kilometres away from their homes. This paper seeks to address the problem by designing and implementing an efficient, cost effective Global System for Mobile Communication (GSM) Controlled Irrigation System (GSMCIS**)** which will monitor and control the water flow of the drip irrigation through communication with an authorized mobile phone operator via text messages. The automatic control component of the system is timer based with an Arduino Uno board and a real-time clock from the SIM900 GSM module. For monitoring purposes, the system sends periodic notification about the humidity sensors planted in the farms and the performance of duty via SMS to the authorized person(s). Moreover, the GSMCIS saves time, labour and reduces cost of operation by easy monitoring and controlling of the farm no matter the distance. GSMCIS is recommended for farmers to monitor their farms in the comfort of their homes.

Keywords: Reduction, Water Wastages, Arduino, DHT Temperature Sensor

1 Introduction

The development of vegetable cultivation in Anloga has been reliant on the use of drip system of irrigation, which was an initiative of the Danish International Development Agency (DANIDA), University of Ghana, and University of Arhus in November 2010. The project aimed at ensuring an all year crop production and increasing vegetable productivity by reducing water wastage by 30-50 percent as compared to the old tube well system (Anon., 2011).

However, most farmlands are located at the outskirts of towns, which makes it difficult to monitor. Apart from the fact that the current system is unable to help farmers monitor farms from the comfort of their homes, it also leads to under-watering and/or over-watering (water wastages) because there is no mechanism that will ensure that the right amount of water has been irrigated. These bring inconveniences on the part of the farmer and eventually decreases productivity. Therefore, there is the need for an irrigation system that ensures that the right amount of water is supplied to a particular crop and also be remotely monitored.

This paper presents the design and implementation of a GSM-controlled irrigation system (GSMCIS), which permits full monitoring of the drip irrigation process using GSM technology. This system uses digital humidity and temperature (DHT) sensors, which collect humidity data (amount of water in the soil) and relay the data to the farmers' cell phones for the appropriate actions to be taken. This system is designed to kick start after 5 minutes of no response from the farmer. Also, since this system uses a GSM module, the farmer can control and monitor his farm globally without necessarily visiting the farm. This system can also go a long way in saving water and electricity and as well eases the farmer's work. Aside vegetable farms, this system is applicable in large agricultural lands, coconut plantations, home environment or industries and colleges where large gardens are to be monitored remotely.

The system is fitted with metering mechanism to check the amount of water irrigated so that the amount and the cost of water used in the process can always be estimated. However, because the system uses wired digital humidity and temperature DHT sensors, farmers will have to exercise caution when weeding the farms.

The base design consisting of digitally metered motor and water control circuits as proposed by Durfee (2011) is manually operated and static. This study improves upon the system's "Smartness".

2 Resources and Methods Used

System prototyping is the main method deployed in this paper. The main tools are System Simulation in Proteus, Arduino Uno board, Arduino Sketch Integrated Development Environment (IDE), SIM 900 GSM Module, DHT11 Digital Temperature and Humidity Sensors, Plastic Water Solenoid

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Valve, Relay and pump system fitted with digital metering system.

2.1 Soil Moisture Sensors for Manual Irrigation Control

Soil water status is determined by direct (soil sampling) and indirect (soil moisture sensing) methods. Direct method of monitoring soil moisture is rarely used for irrigation scheduling because it is intrusive and labour intensive and cannot provide immediate feedback. Soil moisture probes are permanently installed at representative points in the farm to provide repeated moisture readings over time for irrigation management. Special care is needed when using soil moisture devices in coarse soils since most devices require close contact with the soil matrix that is sometimes difficult to achieve in these soils, and as well the fast soil water changes typical of these soils are sometimes not properly captured by some types of sensors Muñoz-Carpena *et al*., (2005).

2.2 System Design

The GSMCIS houses a high speed Atmel Atmega328P microcontroller on the Arduino Uno board and humidity sensors at different spots on the farmland. These sensors are attached to the microcontroller and are controlled accordingly using digitally metered motor and water control circuits based on the proposal by Durfee(2011) Unique to GSMCIS is the introduction of GSM modem for farmer notifications about faults and sensor readings for remote monitoring and control of the irrigation system. Thus, the GSM modem enables the farmer to switch on/off the system and by simply sending and replying an SMS message using the ubiquitous cell phone (mobile phone). When there is a sense of a low humidity of the soil, the farmer, by use of a cell phone is notified and likewise for the increase in the humidity too.

The system operates using a microcontroller for analyses, interpretation, and sending of digital signals to the I/O devices for the system to operate. The prototype system uses a cell phone (mobile phone) for controlling the DC motor operated valves based on reply or return SMS (text message) from any type of phone registered on the system.

Fig. 1 shows the block diagram of the GSMCIS. This comprises of the controller node, actuator node, and sensor node. The flowchart in Fig. 2 depicts the nature and flow of the steps in a process. It helps in the understanding the process and aids in the identifying problem areas and opportunities for process improvement.

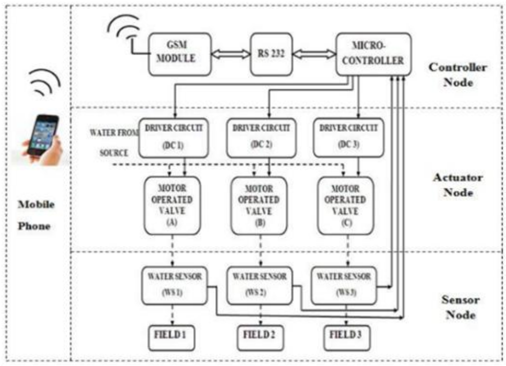

Fig. 1 Block Diagram of GSMSIC

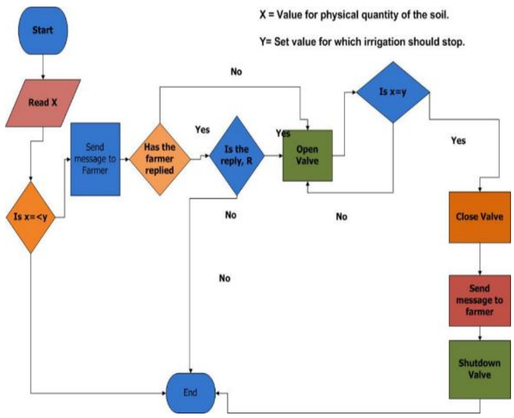

Fig. 2 Flowchart of the System

3 Results and Discussion

3.1 System Operation

The system starts by initialising the microcontroller and displays it on the LCD. After the initialisation, the program codes are then loaded into the microcontroller's memory. The program codes are the instructions that are given to the microcontroller with the help of the Arduino Sketch IDE to function. The microcontroller has been programmed based on the crop type, humidity and temperature of the soil as the physical quantity with respect to the DHT1 sensor. In situations of low humidity, a message is sent from the circuit to the mobile phone of the farmer. By replying the message **(#a0),** the valves with the help of the pump, opens to allow water to flow onto the field and as such the DHT1 sensor continues to check the soil's moisture content through the entire process so as not to exceed the set value. The valve closes automatically when the soil moisture reaches the set standard after a message has been sent through the GSM module to the farmer on his phone and responded **(#a1).** The system continues in this cycle to make sure the moisture contents of the soil are always in range. The interface of the associated mobile phone application is shown in Fig. 3.

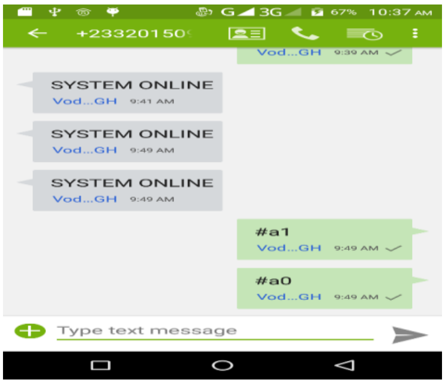

Fig. 3 A Screenshot of Messages Sent to the Mobile Phone

3.2 Programming

The entire project was coded in C using the Sketch IDE which is an open software specifically designed for programming the Arduino microcontroller board. Fig. 4 shows a snapshot of the programming interface.

Fig. 4 Screenshot of the C Programming Interface

3.3 Prototype Building

The prototype of the GSMCIS was built using a sample soil packaged in a box. Six DHT sensors, were lowered in the soil which in turn were connected to the Arduino Uno and the SIM 900 GSM module. Fig. 5 presents the prototype.

Fig. 5 GSMIS Prototyping

3.4 Cost Analysis

The various components needed were purchased online while the locally available components such as jumper cables and some resistors were purchased in Ghana. Nevertheless, there were some components that were not in stock so they were improvised with respect to the functionalities in the system design. Table 1 shows the items purchased and their cost. Installation requires low technical expertise for already installed irrigation system.

Table 1 Cost of Components Used in the Prototyping

Component	Quantity	Unit Price (GH¢)	Price (GH¢)
SIM 900 GSM Module	1	80.00	80.00
Arduino Uno	1	90.00	90.00
Plastic Water Solenoid Valve	1	48.00	48.00
12V Liquid Pump	1	75.00	75.00
DHT11 Digital Temperature and Humidity Sensor	1	30.00	30.00
Relay	1	20.00	20.00
TOTAL			**343.00**

Dollar rate: $ 1.00: GH¢ 3.90 (July, 2016)

We strongly believe the returns on this investment will be massive since farmers will have their comfort and produce all year round.

4 Conclusions

GSMIS will definitely enhance the water distribution in the field. GSMCIS will ensure uniform distribution of water at the appropriate times, reduction in labour cost, prevention of unwanted water spillages (unwanted irrigations when automated), minimization of occurrences of motor faults and intimation to user about the completion of task. The use of mobile phone has become more common among farmers and hence used. GSMCIS proves to be a major advantage and boon to farmers whose pump sets are located far away from their homes due to capability of remote monitoring and control using cell phone and intimation about any abnormal conditions.

The future works in GSMCIS should use spoken commands to help our illiterate. In cases where non-deterministic response of SMS is not acceptable, dedicated voice based call approach can be incorporated.

References

Ahiataku-Togobo, W. M. (2002). "Analysis of Household Cooking Energy in Ghana", *Power Point presentation at the LP Gas Promotion Workshop*, 88 pp.

Anon., (2007), "Gravitech_ATMEGA328 data-sheet", *www.atmel.com*, Accessed: February 3rd, 2016.

Anon., (2011), "Shallot Farming in Anloga", *www.graphic.com.gh/Shallot-Farming,* Accessed: February 3rd, 2016.

Anon., (2014), "Internet of Things", *www.wiki-pedia.org/wiki/Internet_of_Things*, Accessed: January 20, 2016.

Anon., (2015), "Arduino UNO", *www.arduino.-cc/en/Main/ArduinoBoardUno*, Accessed: January 20, 2016.

Anon., (2015), "Sensor", *www.wikipedia.org/-wiki/Sensor*, Accessed: January 10, 2016.

Anon., (2016), "Arduino Shield", *www.arduino.-cc/en/Main/ArduinoGSMModule*, Accessed: January 20, 2016.

Chandrika, C., Surbhi, A., Er, B. and Persis, U. I. (2012), "A Survey of Automated GSM Based Irrigation Systems", *International Journal of Emerging Technology and Advanced Engineering*, Vol. 2, pp. 10 - 12.

Divya, V. and Umama, K. A. (2013),"Smart Irrigation Technique Using Vocal Commands", *International Journal of Engineering and Technology*, Vol. 5, No.1, pp. 385 - 390.

Laxmi, S., Nandini, P., Nikita, M., Shruti, J., Smitha, P. and Swati, C. (2014), "Irrigation Control System Using Android and GSM for Efficient Use of Water and Power", *International Journal of Advanced Research in Computer Science and Software Engineering*, Vol. 4, pp. 40 - 50.

Pavithra, D. S. and Srinath, M. S. (2014) "GSM based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by Using an Android Mobile", *Journal of Mechanical and Civil Engineering*, Vol. 11, No. 4, pp. 10 - 15.

Muñoz-Carpena, R. and Dukes, D. M. (2005), "Automatic Irrigation Based on Soil Moisture for Vegetable Crops*", Institute of Food and Agricultural Sciences Extension,* 4pp.

Rashid, H., Sahgal, J. L., Anshulgangwar, M. R. (2013), "Control of Irrigation Automatically By Using Wireless Sensor Network", *International Journal of Computing and Engineering*, Vol.3, No. 1, pp. 207 - 331.

Sikhjit, S. and Neha, S. (2012), *"*Research Paper on Drip Irrigation Management using Wireless Sensors", *International Journal of Computer Networks & Wireless Communications,* Vol. 2, No. 4, pp. 461 - 464.

Umair, S. M. and Usman, R. (2010), "Automation of Irrigation System Using ANN-based Controller", *International Journal of Electrical & Computer Sciences,* Vol.10, No. 2, pp. 45 - 51.

Atodaria, V. H., Tailor, A. M. and Shah, Z. N. (2013), "SMS Controlled Irrigation System with Moisture Sensors", *Indian Journal of Applied Research*, Vol. 3, No.5 pp. 30 - 40.

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