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Automated Irrigation System

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Abstract: In this paper we aim to improve the use of water in the irrigation process. That is by continuously monitoring the soil moisture level to decide whether irrigation is needed or not. We focus on giving people - who are not familiar with agriculture as well as the farmers - the ability to design an automated irrigation system with all its details. In addition, it determines the required list of components with the total cost based on the market price.

Keywords: Irrigation, automation, soil moisture.

1 Introduction

In a community that faces the effects of dryness, proper irrigation is crucial. Irrigation is the artificial application of water to the soil, in the correct amounts and frequency, for optimal soil infiltration and plant growth [1]. However, farmers face many problems related to this topic. One of the mutual problems that planters deal with is irrigation scheduling: running an irrigation cycle too long and/or beginning an irrigation cycle too early is considered one of the ways of wasting money as well as water. For the same reason, not running the system for a lengthy adequate period of time or starting an irrigation cycle too late is considered under watering, which can cause pauper crop quality and can minimize the yields.
In other words, irrigation scheduling is to decide when and how much water to apply to a field. Its purpose is to resolve the exact timing for application in addition to the exact amount of water to apply to the field. By using a criterion, the quantity of water applied is determined besides the irrigation need [2].

Three methods are used to solve the problem: evapotranspiratio- based control systems, soil moisture or soil water tension-based control systems and a combination of these two methods [3]. The article's focus is on the soil moisture or soil water tension-based control system. For this reason, an automated irrigation system has been designed to continuously monitor the amount of moisture in the soil and to act accordingly. It has to be intelligent enough to solve the issue without the interference of the farmer. The system has to perform the following functions:

1. Continuously measuring the amount of moisture in the soil. This is normally done using sensors dedicated for such purposes. The sensor used in this paper is the YL-69 soil moisture sensor.
2. Stating if the plant needs water based on the data acquired from the soil moisture sensor.
3. Supplying the desired or approximate amount of water to the plant.

Automated irrigation systems have great advantages such as saving money and water. The water needed for irrigation can be from any source i.e. river, pond etc. However, the most desirable source is a water reservoir, which is considered as a large source of fresh water and remains continuously available notwithstanding of variations in weather or climatic conditions.

2 Components and designing the system

The small-automated irrigation system is created using a solar panel, battery pack, Raspberry Pi 3 Model B, rain sensor FC-37, rain capture basin, ultrasonic sensor HC-SR04, mini water pump and soil moisture sensor YL-69.

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2.1 Solar panel

According to Oxford Dictionaries, a solar panel is designed to absorb the sun rays as a source of energy for generating electricity or heating. It is used to recharge the battery pack, which in turn is going to provide the Raspberry Pi electricity to function properly.

2.2 Raspberry Pi 3 Model B

The Raspberry Pi has been around since 2006, and in 2016, the Raspberry Pi Foundation revealed that they had sold over eight million Raspberry Pi devices. This little device allows people of all ages to discover computing, and to learn programing languages such as Scratch (free visual programming language developed by the MIT media lab) and Python. Furthermore, you do not have to worry about turning the Raspi off to save power since it consumes very little power comparing to traditional computers [4].
This model of the Raspberry Pi is the one that is used. As the third generation of Raspberry Pi, it has a powerful processer that is 10x faster than the first generation. It adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

2.3 Sensors

According to [5], a sensor is a device that senses and responds to some type of input from the physical environment. Whereas, the specific input could be moisture, temperature, motion, light or any other physical phenomenon. The signal that can be converted to human-readable display at the sensor location or transmitted over a network for reading electronically is the output.

2.3.1 Moisture Sensor YL-69

The YL-69 moisture sensor (Figure 1), which is made up of two electrodes, reads the moisture content around it. After the current passes across the electrodes through the soil, the resistance to the current determines the soil moisture. The water content in the soil affects the voltage outputted by the sensor itself: when the soil is wet the output voltage decreases, and when it is dry the output voltage increases [6].

Fig. 1: The YL-69 sensor. It is used to read the soil moisture content around it.

It is important to note that it is the best practice to use it in plants that have small roots, or in pots. The YL-69 sensor has the following specifications [7]:

Table 1: YL-69 specifications

Item	Condition	Minimum	Typical	Maximum	Unit
Voltage	-	3.3	/	5	V
Current	-	0	/	35	mA
Output Value	Sensor in dry soil	0	~	300	/
	Sensor in humid soil	300	~	700	/
	Sensor in water	700	~	950	/

Since the Raspberry Pi itself does not have an analogue GPIO pin, an integrated circuit (MCP3008) is used as an ADC (Analog to Digital Converter) to get more precise data.

2.3.2 Rain sensor FC-37

The FC-37 rain sensor is composed of two pieces: the electronic sensor and the electronic board. It is an easy tool for rain detection. It can be used to measure the rainfall intensity and to state whether it is raining or not.

2.3.3 Ultrasonic Sensor HC-SR04

Having a frequency above the human ear's audibility boundary of about 20 KHz is the meaning of the term ultrasonic. Ultrasonic transmitter emits ultrasonic waves in one direction by sending eight 40 KHz of them. When emitted, it starts timing. If the waves encountered an obstacle on their way, the module detects a pulse signal back. After receiving them, the ultrasonic receiver stops timing [8]. Using this procedure, the sensor measures the distance between its location and the encountered obstacle. Measuring of distance is done using the following equation:

$$Distance = \frac{Speed\ of\ sound\ \times Time}{2}$$

Where the speed of sound is equals to 34300 cm/s, and time in seconds. Thus:

$$Distance(cm) = 17150 \times Time(s)$$

The ultrasonic sensor has four pins: Ground (GND), Echo Pulse Output (ECHO), Trigger Pulse Input (TRIG) and 5 Volts Supply (Vcc). Whereas, the GND is connected to the ground pin of the Raspi, the Vcc is connected to the 5 Volts Raspi pin, the ECHO and the TRIG are connected each to a separate Raspi GPIO pin. This device is used in this paper to state whether there is water inside of the basin or not. That is by measuring the distance between its location (located in the basin) and a sponge floating on the water. The sensor output signal on the HC-SR04 is valued 5V, and since the input pin on the Raspberry Pi GPIO is rated at 3.3V, sending a 5V signal into that unprotected 3.3V input port could damage the GPIO pins. For this reason, using a small voltage divider circuit, comprising two resistors, decreases the sensor output voltage to something the Raspberry Pi can handle.

3 Assembling the project

After knowing the common problem that farmers face in irrigation, it is crucial to find a way to solve it using technology as well as programming. Therefore, nothing is better than using sensors to sense the outer environment and act accordingly. For this reason, finding a suitable device to measure the humidity of the soil is necessary. After searching on devices that do not cost a lot of money and can meet the requirements, YL-69 humidity sensor is the chosen one. The second step is to find a suitable microprocessor for it, which is considered as the brain. Two of the most known and usable brains are the Arduino and the Raspberry Pi. Both of them can handle the sensor as well as other devices. Arduino is cheaper than the Raspi since the second one is a credit-sized computer, which means that it is composed of the same hardware contained in a normal computer. For the design process and as phase one (Figure 2) an YL-69 sensor and a Raspberry Pi 3 Model B are used.

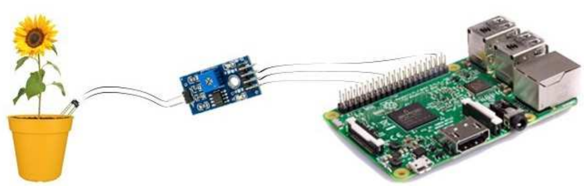

Fig. 2: Phase one of the design, the YL-69 sensor connected to the Raspberry Pi 3 in order to read the soil moisture.

As an initial design, it is a good start. However, the design is promoted after analysis. First, the YL-69 sensor is a digital sensor, which means that it is not able to read values; instead, it reads zeros and ones. In other terms, if the soil needs to be watered then the sensor reads one otherwise, it reads zero. That is why it is necessary to convert the sensor from digital to analog. This is done using an IC called MCP3008. Moreover, it is compulsory to inform the farmer to water the plant in case of need and that is by sending a notification to the planter's phone. These improvements are included in the phase two of the design. After analyzing the phase two, informing the farmer to water the plants *by himself* is not effective. Sometimes, the farmer is going to water them without knowing the exact quantity of water needed to the plant. Not to forget that it happens sometimes where the farmer is busy and unable to water all of the plants. Consequently, a new idea comes up, which is making an automated irrigation system that acts alone without the interference of the farmer.

The focus in the third phase is to search for devices that meet the requirements of an automated system. One of the devices is the water pump that pumps water under certain conditions, and is controlled by a channel relay connected to the Raspberry Pi. The second device is a rain sensor that states whether it is raining or not. If it is, the basin opens to capture the rain. In addition, a motor is needed to open it. The third phase of the design (Figure 3) is as follows:

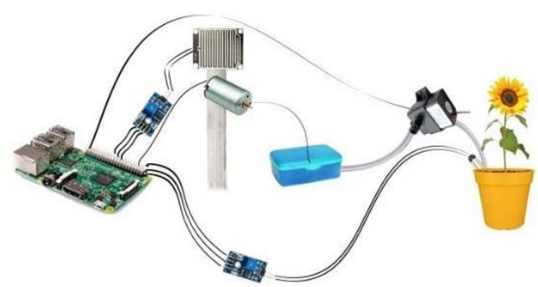

Fig. 3: Phase three of the design, adding rain sensor, basin, mini water pump and a motor in order to create the automated system.

One more update is desired. The Raspberry Pi needs electricity to function properly, which is normal since it is a credit-sized computer as mentioned previously. Therefore, powering the Raspberry pi is essential. It is normally powered using a suitable adapter. In this case, it might be used where there is no electricity. For this reason, the design is promoted by adding a solar panel and a battery pack. The panel charges the battery, which in turn powers the Raspberry Pi. It is very important to note that this is only a prototype, which can be developed.

4 C# Application

A C# application has been designed and developed in order to receive notifications from the Raspberry Pi about the status of the plant and the level of water inside the water tank. In addition, it has the ability to calculate the total number of components needed in a specific field as well as the total cost of all of the components according to the market price. The application has the following interface:

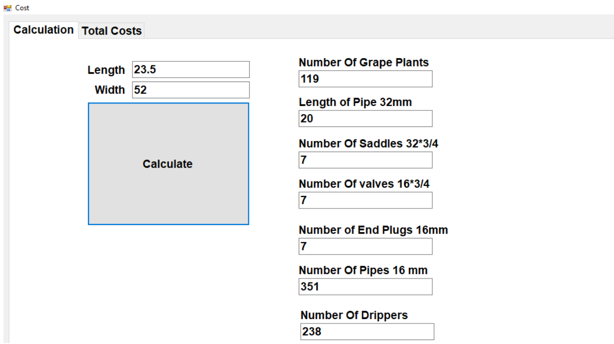

Fig. 4: Calculation section, calculating the number of components and plants according to the width and length of an empty field.

In figure 4, the user inputs the length and width of an empty field in meters. When clicking calculate, the results show up in the fields at the right. To know the total cost of the components, the user can simply click on the total costs section to view the cost (Figure 5).

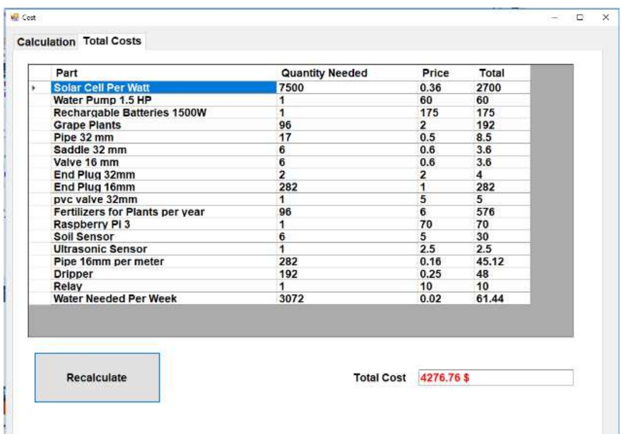

Fig. 5: Total cost section, which shows the total cost of the components according to the market price.

5 Results and conclusion

Nowadays, people and especially farmers are struggling with major problems in watering their agricultural fields. It is because they have no idea about when and how much water to apply to their field. The performance of the project is dependent on the output of the humidity sensors. We are able to irrigate the desired field with the necessary amount of water. The system is successfully designed and assembled. It serves to reduce the consumption of water used. It can be installed easily in the field, requires little resources and the farmer can use it from anywhere in the world according to his needs. The amount of water needed to irrigate the plants decreases from a range between 70 to 80 liters, to a range between 32 to 16 liters, which is approximately equals to 60%. Moreover, it solves the irrigation scheduling problem which is one of the most known problems in irrigation. Not to forget that using an automated system will substitute the interference of the farmer and automatically free him to take care of his postponed businesses. Secondly, it is based on solar panel, which means that the farmer can use it without the need of the electricity since the panel takes care of this issue. Finally, yet importantly, it helps him to economize and that is because he does not need to pay electricity bills. The proposed controller eliminates the manual switching mechanism used by the farmers. The irrigation system layout should be checked regularly to avoid clogging of pipes and emitters and the necessary repairs and maintenance should be carried out.

References

[1] O. W. Israelsen, Irrigation Principles and Practices, Second Edition, New York: John Wiley & Sons, Inc (1956).
[2] I. Broner, Irrigation Scheduling, Colorado State University, Fact Sheet No. 4.708 (2016).
[3] C. Shock, R. Flock, E. Eldredge, A. Pereira, and L. Jensen, Irrigation Scheduling of a Water Stress Sensitive Crop, Lessons from Potato (2005).
[4] M. Richardson and S. Wallace, Getting Started with Raspberry Pi, San Francisco: Maker Media Inc. (2016).
[5] P. Naik, N. Telkar and K. Kotin, Survey on Wireless Sensor Network with their remaining Challenges,International Journal of Scientific Research in Science and Technology, Vol. 2, No. 6, pp. 321-331 (2016).
[6] S. Rawal, IOT based Smart Irrigation System, International Journal of Computer Applications, Vol. 159, No. 8, pp. 880-886 (2017).
[7] A. Shakoor, Z. Khan, M. Ahmad, and M. WAJID, Design and Calibration of Semi-Automated Irrigation System Based on Soil Moisture Sensor, 1st National Conference on Agricultural Engineering and Sciences (NCAES), Vol. 1 (2016).
[8] N. Sharma, N. Singha, and T. Dutta, Smart Bin Implementation for Smart Cities,International Journal of Scientific & Engineering Research, Vol. 6, No. 9, pp. 787-791 (2015).

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