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AUTOMATIC VARIATION PLANT DETECTOR USING AQUAPONIC CONCEPT

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Abstract

The farmers manually control the irrigation system in agriculture especially in small-scale area. Sometimes it can lead to either inadequate or excessive amount of water supplied to the plant. This project is designed to help in water conservation by watering the plants using aquaponic concept. The aquaponic concept is about growing fish and plant together in one re-circulating system. Since the heat stress and heavy rain can affect the plant growth, thus this project is equipped with the sensors to control the excessive amount of water and heat to the plant. There are three main sensors used in this project, which are soil moisture, rain and heat sensors. The soil moisture sensor circuit diagram controls the watering system for the plant. If the soil gets dry, the fish tank water will be supplied to the plant by using motor/water pump. The rain and heat sensor circuits help to detect excessive water and heat stress to the plant. These circuits will trigger the roof/shelter to shade the plant.

Keywords: *Moisture sensor; Rain sensor; Heat sensor; Aquaponic;*

1.0 INTRODUCTION

Most of the previous works only focus on the irrigation system for the plant. They have reported the usage of microcontroller instead of integrated circuit (ICs) due to several advantages (Darshna, Sangavi, Mohan, Soundharya & Desikan, 2015; Gupta, Kumawat, & Garg, 2016). For example, these microcontrollers may reduce size, cost and complexity of a circuit which makes them preferable eventhough the power consumption and performance of a circuit by using ICs is better (Lundager, Zeinali, Tohidi, Madsen, & Moradi, 2016). Moreover, this microcontroller requires both hardware and software to perform specific task. In this work, the automatic variation plant detector is designed by using several ICs to overcome not only the watering system problem using aquaponic concept, but also precisely control the effect of heavy rain and heat stress to the plant. This project comprises three main sensor circuits, which are soil moisture, rain and heat sensor. The moisture sensor is used to sense the level of moisture in the soil. In this circuit, the motor/water pump is used to supply enough water to the plant by using fish tank water. This is called as aquaponic concept where fish and plant grow together in one re-circulating system. The rain sensor is used to detect presence of excessive water on the plant especially during rainy days. Meanwhile, the heat sensor is used to detect intense sunlight towards the plant. Both circuits do the same action where they will trigger the roof/shelter to shade the plant.

2.0 BACKGROUND/LITERATURE REVIEW

Studies have shown that intensive care such as adequate watering system, light, temperature and humidity are needed for the plant growth to go well (Carson, Shimizu, Ingels, Geisel, & Unruh, 2002). Improper watering system for the plant especially presence of excessive water can result in similar stresses to the plants as drought (Al-Bahadly & Thompson, 2016, Carson et al, 2002). If the light level is too high, plant leaves show an overall yellowing due to the destruction of green pigment. The plant will have smaller leaves and less vivid color if the light intensity is insufficient.

The existing methods use microcontrollers in designing automated plant watering system. These methods mainly consist of two important fractions which are hardware and software development (Gupta et al., 2016; Devika, Devika, Khamuruddeen, Khamurunnisa, Thota, & Shaik, 2014; Al-Bahadly & Thompson, 2016). There are several types of microcontrollers that have been used in designing the irrigation system. For example, Divani et al. have reported the usage of Atmega328 microcontroller in designing their proposed project. This automated plant watering system is designed with a soil moisture sensor connected to an Arduino microcontroller board. This Arduino board functions as a brain that is used to receive information from the sensor and comes out with an instruction in term of response (action) as the feedback. It is programmed using an integrated development environment (IDE) software (Divani et al., 2016). Another automated watering system project reported by Gupta et al. is based on PIC 16F877A microcontroller which is programmed with the KEIL software (Gupta et al., 2016). Meanwhile, Al- Bahadly et al. used a Teensy 2.0 microcontroller where the code is written in C programming language and programmed via a USB cable (Al-Bahadly & Thompson, 2016). However, the main issue in designing a project based on these microcontrollers is the compatibility of the instructions in programming (software) to interface with the hardware.

Recently, aquaponic has received great attention from researches due to its advantages in agriculture. The word ‘aquaponic’ refers to the integration of ‘hydroponic’ (growing plant without soil) with aquaculture (fish farming) (Saaid, Fadhil, Ali, & Noor, 2013). The usages of aquaponic concept in designing automated plant watering system have been reported in a few studies. For example, Saaid et al. have successfully designed an aquaponic project based on the application of microcontroller. They have studied the growth performance between the comet goldfish and hydroponics plant (water spinach). Based on their findings, they have proved that both fishes and plants could successfully grow in one re-circulating system. This helps to avoid water wastage since the water is reused within the system (Smit & Schutte, 2008). Besides, there is no chemical fertilizer used to feed the plant except for the fish fertilizer which acts as nutrient for the plant (Saaid et al, 2013: Patillo, 2013). Plants absorb the nutrient rich water supplied by the fish tank water instead of water pipe. Then, the filtered water is returned back to the fish tank. This concept also reduces the wastage of water.

Based on these literatures, this project is designed by using several ICs instead of microcontrollers. The watering system for the plant is based on the aquaponic concept due to its several advantages. Moreover, the effects of heat stress and heavy rain can be controlled.

3.0 METHODOLOGY

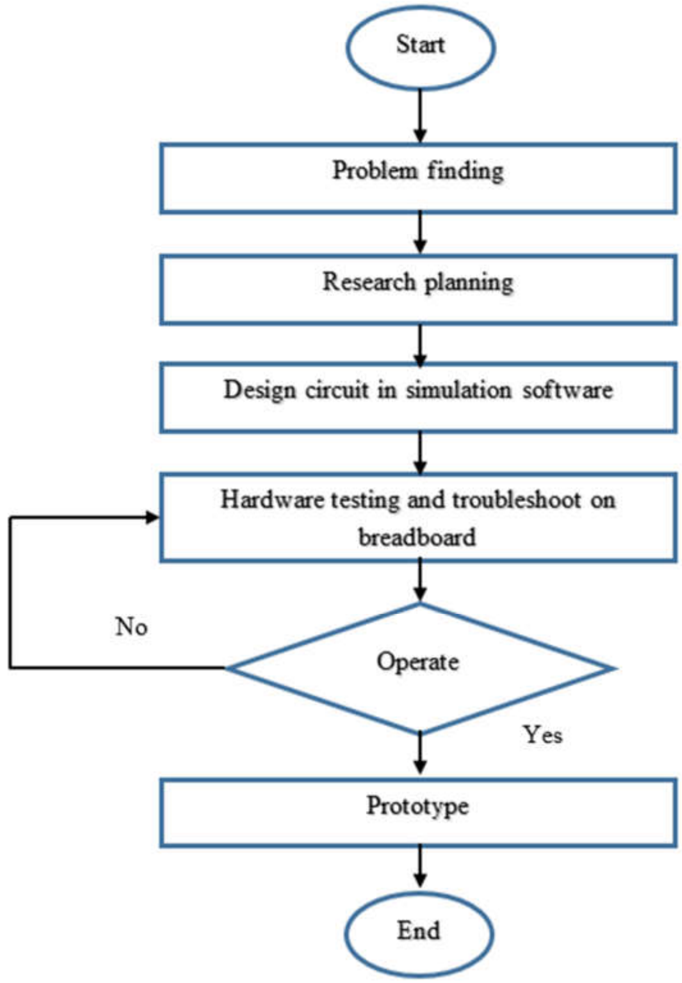

Figure 1 Flowchart of the project

Figure 1 shows the flowchart of the overall project. This project started by identifying the problem faced in agriculture. Then, the research planning was carried out by conducting some literature reviews. The objectives and scope of works were identified. The schematic diagrams of the three main circuits were designed using Proteus software. Once the simulation worked, the components were constructed on the breadboard. The circuits were tested to verify their functionality. Next, the testing and troubleshooting process were carried out to identify the operationally of the board. Once the circuits worked successfully, the prototype of the project was built.

3.1 HARDWARE DESIGN

Figure 2 shows the schematic diagram of soil moisture sensor, where the circuit was tested by dipping the probe sensor into the water. The moisture circuit consists of IC NE555 timer and OP AMP LM324 as a comparator. To test the functionality of the three circuits, the LED was used as the output to replace DC motor. A 12-volt battery drove the DC motor. In the moisture circuit diagram, the DC motor is used to pump the water from the fish tank for the plant. In this circuit, bowl of water is used to replace the soil. Once the probe sensor was dipped into the water, the LED blinked and thus proved that the circuit worked.

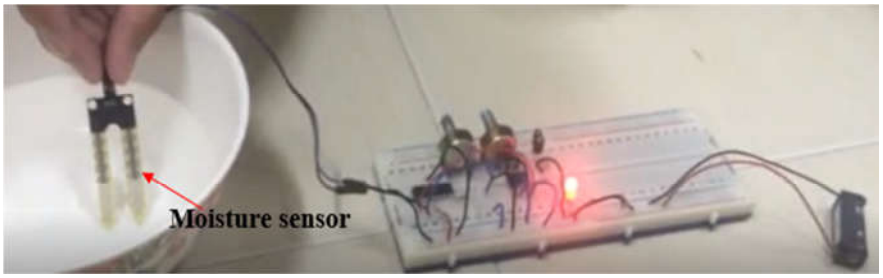

Figure 2 Soil moisture sensor circuit diagram tested on breadboard

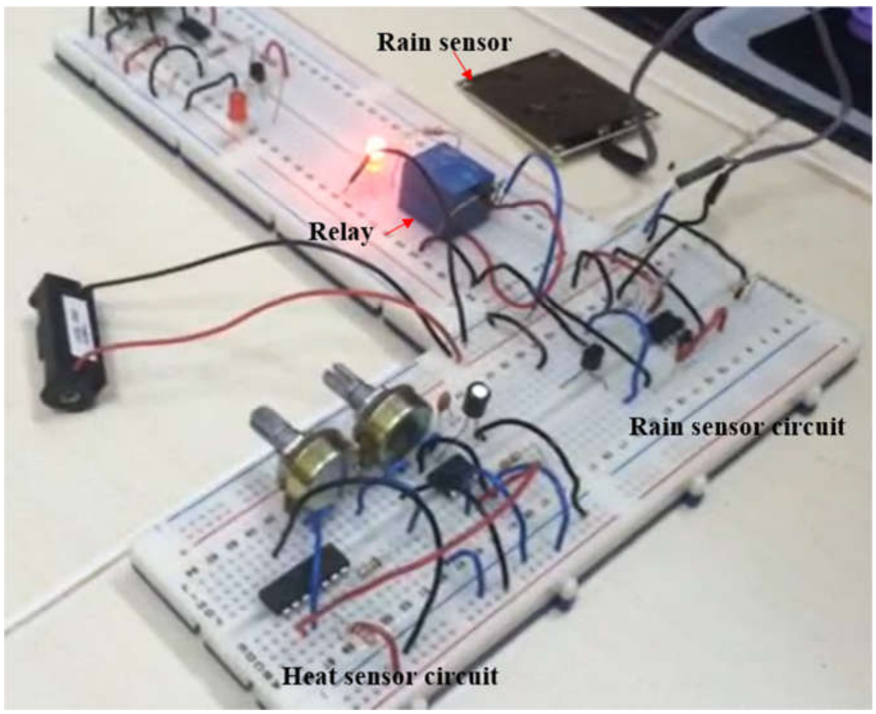

Figure 3 Rain and heat sensor circuit diagrams tested on breadboard

Figure 3 shows the combination of rain and heat sensor circuit diagrams which are connected by L239D IC to move the DC motor. In the rain sensor circuit, the IC NE555 acts as a timer. This IC works in monostable mode. It is called as monostable mode because it produces only one output pulse for a certain length of time. The probe of the rain sensor is connected to the second pin of the IC. If a small amount of water is dropped to the rain sensor, it will connect the negative voltage to trigger the pin of IC 555, which will turn on the output of 555 to the high mode. As shown in Figure 3, the LED blinked once the probe sensor detects even a small amount of water. In this circuit, the LED was used as the output to replace DC motor in order to move the roof/shelter for the plant. The IC LM741 has been used in the heat sensor circuit. The temperature was set by adjusting the variable resistor. The IC L239D has been used for both circuits to control direction of DC motor either in forward or reverse direction. This IC is also called as IC dual H-bridge motor driver. Both circuits are connected together to trigger the DC motor to move roof/shelter for the plant. If the heat sensor detects high temperature from surrounding, it triggers the DC motor to move the roof in forward (close) as a shelter to the plant and vice versa.

3.2 MECHANICAL DESIGN

Figure 4 Prototype of the project

Figure 4 shows the prototype of the project. To test the functionality of the circuit, this project was demonstrated only in a small-scale area. The watering system to the plant was controlled by the moisture sensor circuit. Once the moisture sensor probes sense dryness of the soil, it will trigger the water pump to supply enough water to the plant. Meanwhile, the rain and heat sensor circuits did the same action to trigger the DC motor.

4.0 RESULT AND DISCUSSION

The moisture sensor is used to check dryness of the soil, thus it is placed into the pot. Once the probe of the sensor is merged to the soil and detects the low level of moisture, it will trigger the relay to open the switch and close the circuit. Thus, the circuit is turned on due to the flow of current. This current is then supplied to the water pump. Automatically, the water from fish tank is supplied to the plant through PVC pipe. The water supply process to the plant is stopped once the soil gets wet. Excessive amount of water especially due to rainy days will turn on the rain sensor circuit system. The circuit then triggers the DC motor to move the roof in forward direction (close). This roof acts as a shelter for the plant. However, the circuit is turned off if there is no water detected by the rain sensor probe. Thus, the DC motor will move the roof in reverse direction (open) or back to normal. Meanwhile, the heat sensor system operates once the sensor detects high temperature from surrounding especially direct intense from sunlight. The optimum temperature is adjusted based on the plant's need. If the sensor detects high heat or temperature, it will trigger the DC motor to move the roof in forward direction (close) and vice versa. Table 1 shows the summary operation of these three circuits.

Table 1 Summary operation of the circuits

Sensors	Operation of motor	
	Operate	**Do not operate**
Soil moisture sensor	Soil is dry	Soil is moist
Rain sensor	Presence of water	Absence of water
Temperature/ heat sensor	High temperature	Low temperature

5.0 CONCLUSION

As a conclusion, by having this project, the treatment of the plant in term of its watering system allows the control of heat stress and heavy rain effects. Besides, it helps in water conservation since the watering system used in this project is based on the aquaponic concept. The fish tank water supplied to the plant is enriched with nutrients that may help in the plant growth.

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