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Design of Automatic Control System for Garden Plantations Based on Soil Moisture, Temperature and Light Sensing

Beza Negash Getu, Mutasim Alhalawani, Mohammed Atiyah, Adel Alkadri and Mohammed Zakri
Department of Electrical, Electronics and Communications Engineering (EECE),
American University of Ras Al Khaimah (AURAK), Ras Al Khaimah, UAE

Abstract: This system is designed with the aim to facilitate the farmer or gardener to engage in greenhouse plantations and improve agricultural production. The main focus is to design an automated 'Green House' system which is a smart technology to supply garden plantations grown in a certain green house or similar garden area with the required amount of water, temperature and sunlight and avoid damage of the plantations due to over or under supply of this particular plant nourishments. The system monitors and controls the soil moisture, temperature and light intensity based on the three sensors and the Arduino module that automatically controls a water pump, a fan and a lighting fixture based on the sensor information in the greenhouse.

Key words: Soil moisture, light intensity, temperature, Arduino, green house, automatic garden monitoring

INTRODUCTION

Light, temperature and soil moisture (soil humidity) are among the most significant requirements necessary for plant growth. Now a days, due to the increase in construction of buildings, industries, transportation facilities, the available land space is decreasing and hence there is a strong tendency to cultivate plants (flowers, vegetables, fruits and etcetera) in a compact space like green house. There has been popularity and rise of greenhouse environmental control by using computer based systems (Yang and Simbeye, 2013). However, the existing computer-based systems are often unavailable for small-scale grower, home or private uses since they are unaffordable for the low income grower, the device is bulky, difficult to maintain and less accepted by the technologically unskilled workers. Automatic controlling systems designed using easily available discrete components are also proposed by Getu and Attia (2016), Getu *et al*. (2015). Automatic irrigation systems can be programmed to discharge more precise amounts of water in a targeted area which promotes sustainable use and conservation of water as water consumption is increasing because of population growth and increased food demand. As water is one of the scarce natural resources, it is important to properly use and manage our usage in different sectors and hence there is a need to design systems that are used to monitor and control our water usage including in homes, agriculture and industrial sectors (Getu and Attia, 2016, Getu, 2016). While by Getu *et al*. (2015), the Dual Tone Multi-Frequency (DTMF) signalling technique in telephones is used to control switching state of agricultural pumps located in remote areas by Getu and Attia (2016), the speed of the motor water pump and the duration of motor working time is varied according to the level of the soil moisture content to provide necessary amount of water to plants depending on the soil conditions. On the other hand, the wide spread use of microcontroller-based systems is increasing since it is becoming cheaper, less bulky and consumes less power than the computer-based control systems (Sahu and Mazumdar, 2012; Jia *et al*., 2012, Devika *et al*., 2014, Nagarajapandian *et al*., 2015, Ojha *et al*., 2015, Vashista *et al*., 2016). For example, in the system designed by Jia *et al*. (2012), farmers can get the information about the water level from sensors placed in paddy fields and a farmer can control the motor water pump using a microcontroller by sending a message from his cellular phone even from a remote place. Therefore, considering the versatility function and advantages offered from microcontroller an economic investigation of microcontroller-based systems are being utilized and implemented for cultivation of agricultural and horticultural plants and crops to help small-scale grower or gardener in the world. In particular, the papers (Devika *et al*., 2014, Nagarajapandian *et al*., 2015, Vashista *et al*., 2016) consider the Arduino based microcontroller system to monitor and control an agricultural environmental conditions. The Arduino board is the back bone or the core part of the whole system as

Corresponding Author: Beza Negash Getu, Department of Electrical, Electronics and Communications Engineering (EECE), American University of Ras Al Khaimah (AURAK), Ras Al Khaimah, UAE

it provides an interface between the analog sensors and digital systems while it also does calculations andother functions fordetermining the task to be executed by the different modules of the system (Arduino Company).

The aim of this research is to design and build a very low cost Arduino-based automatic garden monitoring system based on moisture, temperature, light sensors (Spark Fun Company, Sunrom Company, Texas Instruments Company) and provides appropriate water, cooling and light to the plants in a garden or green house system in accordance to the sensor information for the particular environmental condition. The final product is to be built from low cost components to acquire a very cheap system which can be easily serviced or replaced. It should be reliable enough that it can work for a basic garden or vegetable patch for several months without any human intervention and should only use minimal power and minimal water for cost and sustainability reasons.

System overview: The proposed system is intended to control three different parameters (soil moisture, temperature and light status) of a certain garden or green house planation that are vital for the healthy growth of plants as shown in the block diagram in Fig. 1. The Arduino is central controller of the overall system and it will show the readings from the water moisture sensor the temperature sensor and the light sensor and give the order to switch on or off the water pump, the fan and the lighting fixture (light source) according to the environmental readings. The system is designed to do the following:

- Water the plants whenever their soil moisture level drops below a predefined or preset value
- Turns on lights but only when it’s dark
- Alerts the user if the temperature around the plants increases above a certain preset temperature value and turn on the fans for cooling the plants. The preset temperature is chosen depending on the requirements of the plants so that they are not affected by any excess heat which may affect their metabolism and healthy growth

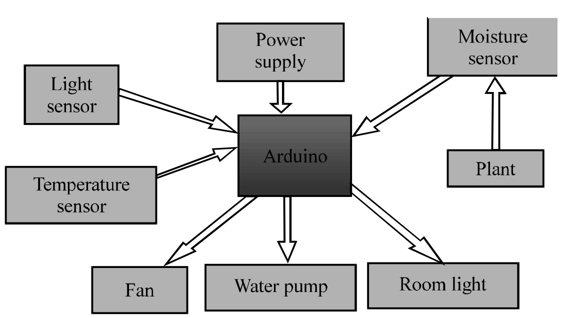

Fig. 1: Block diagram overview for the overall system

The system is flexible in that the preset temperature or moisture levels could be modified if needed by the user depending on the requirements. By changing the Arduinocode, any desired level could be programmed by the user.

MATERIALS AND METHODS

This system contains the following components: the microcontroller which is the Arduino Uno, the temperature sensor which is the LM35, the soil moisture (humidity) sensor which is the SparkFun soil moisture sensor, small signal switching transistors, relays, a water pump, a fan and artificial lighting fixture.

Light, temperature and moisture sensors: For light sensing, we have Light Dependent Resistor (LDR) as shown in Fig. 2 as a sensor. LDR is very useful especially in light/dark sensor circuits. Normally, the resistance of an LDR is very high can be in the order of Mega ohms (MΩ) but when they are illuminated with light resistance drops dramatically, allowing more current to pass through it (Sunrom Company).

Through this sensor, we can detect the light and dark states or possible to determine how many hours of light the plants received using the Arduino by counting lighting duration so that it can be decided whether the artificial light is to be switched on for a required amount of additional time.

For temperature, we have LM35 (Fig. 2) temperature sensor. LM35 is a precision integrated-circuit temperature device with an output voltage linearly proportional to the Centigrade temperature. It does not require any external calibration and provide high accuracy over a full, 55°-150°C temperature operating range (Texas Instruments Company). When the system detects a temperature more than a certain preset level, the fan will be turned on to provide the required cooling until the temperature drops below the preset level.

For soil moisture sensor, SparkFun Soil Moisture Sensor is used (Fig. 2) which is a simple breakout for measuring the moisture in soil and similar materials (SparkFun Company). The soil moisture sensor is pretty straight forward to use. The two large exposed pads function as probes for the sensor, together acting as a variable resistor. The more water that is in the soil means

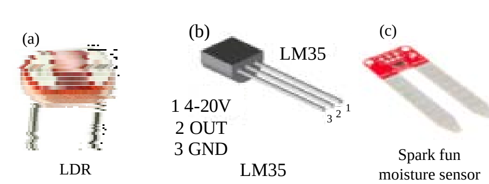

Fig. 2: Light, temperature and moisture sensor

the better the conductivity between the pads will be and will result in a lower resistance and a higher SIG out (which is a voltage signal). To get the SparkFun Soil Moisture Sensor functioning, the VCC and GND pins of the sensor are connected to the corresponding pins in the Arduino board and there will be a SIG out which will depend on the amount of water in the soil. The state of the water pump (on/off) will be determined by the moisture level obtained from the SIG out and detected by the Arduino.

Circuit connections to the arduino: All the sensors, the water pump and the lighting fixture are connected to the Arduino Uno board as shown in Fig. 3. The Uno is a microcontroller board based on the Atmega 328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, USB connection, a power jack an ICSP header and a reset button (Arduino Company). It contains

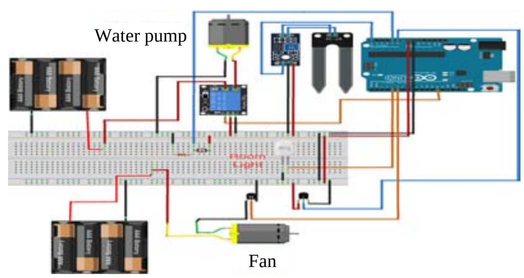

Fig. 3: Circuit connections to the Arduino board

everything needed to support the microcontroller. It can be simply connected to a computer with a USB cable or can be powered separately with an AC-to-DC adapter or battery to get started. For this system, any 5 V power supply could be used to power the Arduino Uno which gives the needed power to make the sensors work. In the prototype a 5 V battery is connected to the Arduino.

The Arduino Uno is connected and programmed to the sensors and to the hardware devices related to each sensor. The circuit and the devices are to be protected and isolated from the garden so that the water supply doesn't leak and threatens to damage the components and the overall system. All the components are tightly fixed on a wooden base, surrounded with wooden board and glass from the sides and a glass roof top to allow light through the glass in the day time so that the plants get the light they need in the day time. When it is dark, the LDR sensor will give the readings to the Arduino Uno which will turn the artificial lights on; 2 fans are also fixed on the side wooden board and they will automatically work when needed (as programmed in the Arduino) when temperature is equal to or above a preset value and will automatically stop working if temperature is less than the preset value based on the temperature sensor readings. The water pump which is located on the separate room but having a pipe connected to the farm room to let water go throw it, works automatically when the moisture is below the threshold preset value. The working of the whole system is programmed in the Arduino as shown in the flowchart diagram in Fig. 4.

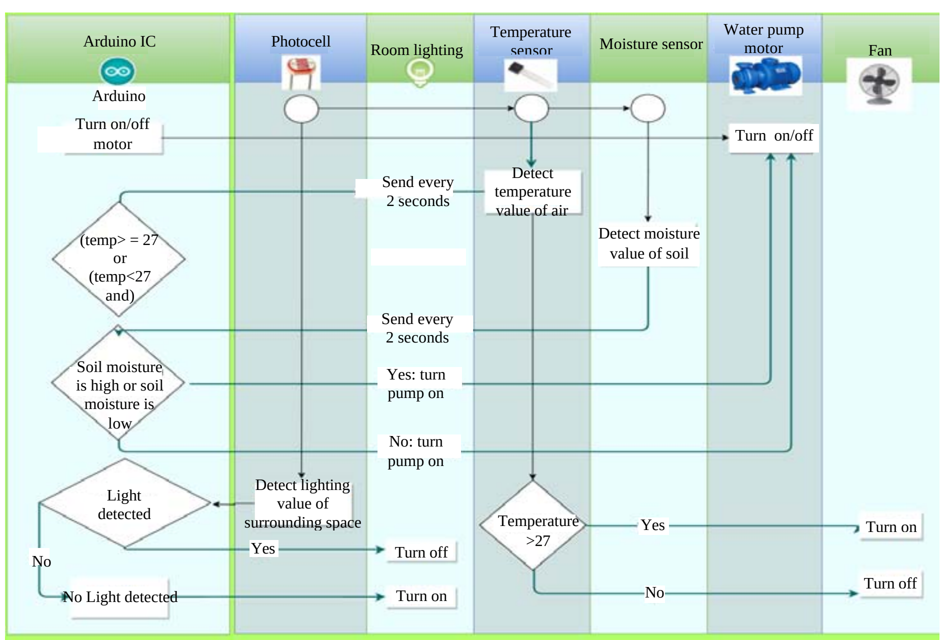

Fig. 4: Flowchart diagram showing the working of the overall system

RESULTS AND DISCUSSION

As part of the requirement for senior design project and as discussed in the above section, an automatic control system for garden plantations in a green house was designed, built and tested in the laboratory as shown in Fig. 5 and it was found that the system works properly. The Arduino Uno was programmed for preset values of light, temperature and soil moisture conditions which can be simply changed in the program (Arduino software).

The LDR senses the light intensity and sends the readings to the Arduino Uno board which is connected to the artificial light bulb. When it is dark, the Arduino Uno will send a signal to the light bulb to be switched on and when there is light (sunlight) the light bulb will be switched off by the Arduino Uno.

The LM35 is used as a temperature sensor which will measure the temperature of the surrounding air and send the readings to the Arduino. The Arduino is programmed to turn on the fans when the temperature is more than or equal to 27 degree Celsius (temperature used for testing). If the temperature is <27 degrees the Arduino will send a signal to the fans to be switched off. When the fans are turned on a red LED will be turned on to show the status of the temperature.

The moisture sensor provides the measurement of the level of the soil moisture which are divided into two levels (high and low) for testing purposes. The Arduino is be able to differentiate between the two levels according to the programming code. When the moisture level is low, the Arduino gives the command to the water pump to be turned on and another LED is turned on to show the status of the water pump. When the moisture level is high the command to turn off the water pump is executed by the Arduino. A relay together with Arduino command is used to control the water pump which will be running with an external power source.

The prototype is designed and built with low cost components and it achieves automatic garden monitoring (moisture, temperature and light) without human intervention uses water efficiently by minimizing wastage that arises as a result of the manual irrigation as there is a lot of water consumption in the agriculture sector. Hence, it will contribute to environmental sustainability through water conservation. The farmer or user achieves efficiency and productivity through using such automation technique. Especially in the farming industry, farmers are using a huge amount of water and lots of labor which means that they are having so many expenses, therefore deploying such automatic irrigation control systems reduces cost of production, simplify the life of farmers and at the same time increase efficiency and productivity of crops.

Fig. 5: Prototype green house automatic control system built in the laboratory

Other alternative designs (computer based and network based) or advanced components such as replacing the type of sensors can be done at the expense of higher cost and complexity but with better performance. For the design, we could exchange the power supply from battery with a renewable and environmentally clean energy source such as solar power which could be located on the roof of the garden at the expense of additional cost.

Finally, during the research and the execution of this project, the group members learned and gained a lot of experience in many cases such as team work, knowledge and skills in working with practical electronics design and implementation, testing and validation, software coding, working on and programming a microcontroller (Arduino Uno), research and literature study, project and time management and technical report documentation.

CONCLUSION

This study presents an automatic controlling system for garden plantations in a greenhouse or similar area to control and supply the required level of soil water, temperature and light for the plants which are vital requirements for the proper and healthy growth of plants. It is implemented and tested using light, temperature and soil moisture sensors with the Arduino Uno microcontroller as the core part of the system. The system is essential for farm productivity and saves human labor and time from automation. Such systems ensure providing sufficient level of water in the gardens avoiding shortage and excess of water for the plants. In doing so, water is saved, consumed properly and in a sustainable way.

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