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Automated Greenhouse Monitoring using Control Systems

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***Abstract:** Greenhouses are climate-controlled structures with walls and roof specially designed for offseason growing of plants. Most greenhouse systems use manual systems for monitoring the temperature and humidity which can cause discomfort to the worker as they are bound to visit the greenhouse every day and manually control them. Also, a lot of problems can occur as it affects the production rate because the temperature and humidity must be constantly monitored to ensure the good yield of the plants. Internet of Things is one of the latest advances in Information and Communication Technologies, providing global connectivity and management of sensors, devices, users with information. So, the combination of IoT and embedded technology has helped in bringing solutions to many of the existing practical problems over the years. The sensors used here are moisture sensor, DHT11 (Temperature & Humidity sensor) and Ultra Sonic sensor. From the data received, Arduino Uno R3 automatically controls Moisture, Temperature, and Echo efficiently inside the greenhouse by actuating an irrigating pipe, cooling fan, and buzzer respectively according to the required conditions of the crops to achieve maximum growth and yield. The recorded temperature, humidity, soil moisture level and echo are stored in a cloud database called ThingSpeak, and the results are displayed in its webpage, from where the user can view them directly.*
***Keywords:** Greenhouse, Monitoring, Control systems, Arduino UNO R3, ThingSpeak.*

I. INTRODUCTION

A greenhouse (also called a glasshouse, or, if with sufficient heating, a hothouse) is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external temperature, protecting its contents in cold weather. The warmer temperature in a greenhouse occurs because incident solar radiation passes through the transparent roof and walls and is absorbed by the floor, earth, and contents, which become warmer. As the structure is not open to the atmosphere, the warmed air cannot escape via convection, so the temperature inside the greenhouse rises. This differs from the earth-oriented theory known as the "greenhouse effect". Quantitative studies suggest that the effect of infrared radiative cooling is not negligibly small and may have economic implications in a heated greenhouse. Analysis of issues of near infrared radiation in a greenhouse with screens of a high coefficient of reflection concluded that installation of such screens reduced heat demand by about 8%, and application of dyes to transparent surfaces was suggested. Composite less-reflective glass, or less effective but cheaper anti-reflective coated simple glass, also produced savings. This system will allow for real-time monitoring of the greenhouse environment as well as automated control measures for temperature, humidity, soil-moisture and echo.

Monitoring the above mentioned parameters also will help understand the growth of plants better. There are many applications of the system ranging from growth of exotic plants, protection of plants from unfavourable conditions, etc.

Paper is organized as follows. Section II describes existing systems and their issues. The flow diagram and block diagram represent the step of the algorithm. After reading of data, how the system transmits the data and performs control measures is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. RELATED WORK

From the data's received, Raspberry PI3 automatically controls Moisture, Temperature, Humidity efficiently inside the greenhouse by actuating an irrigating pipe, cooling fan, and sliding windows respectively according to the required conditions of the crops to achieve maximum growth and yield. The recorded temperature and humidity are stored in a cloud database (ThingSpeak), and the results are displayed in a webpage, from where the user can view them directly [1]. The method is not feasible as Raspberry pi is comparatively more costly than Arduino and Arduino is more user friendly.

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The proposed system receives three parameters from the sensors and activates the actuators if the actual values are more than the threshold values and also stores these values in the cloud database enabling them to be accessed from anywhere, anytime but is not real-time as it is based on request process. [2] suggests the use of temperature, humidity, and CO2 as the parameters for the greenhouse environment. In [11], the system used to optimize crop growth in farming is called protected cultivation, which controls soil and climate, ecosystems by modifying soil, temperature, humidity, sunlight, wind, and air condition. The reason for developing this system is that plants do not have to grow in their original environment. The effects of which are faster plant growth, shorter harvest periods, longer plant life, improved yield quality, sustainable production, and can be developed on limited land, also not meant for monitoring.
The work in this paper is divided in two stages. 1) Monitoring 2) Controlling. The proposed system incorporates both monitoring and control systems in the same system which automates the whole process and eliminates the need for human intervention making the efficiency higher.

III.METHODOLOGY

A. Block Diagram of the system

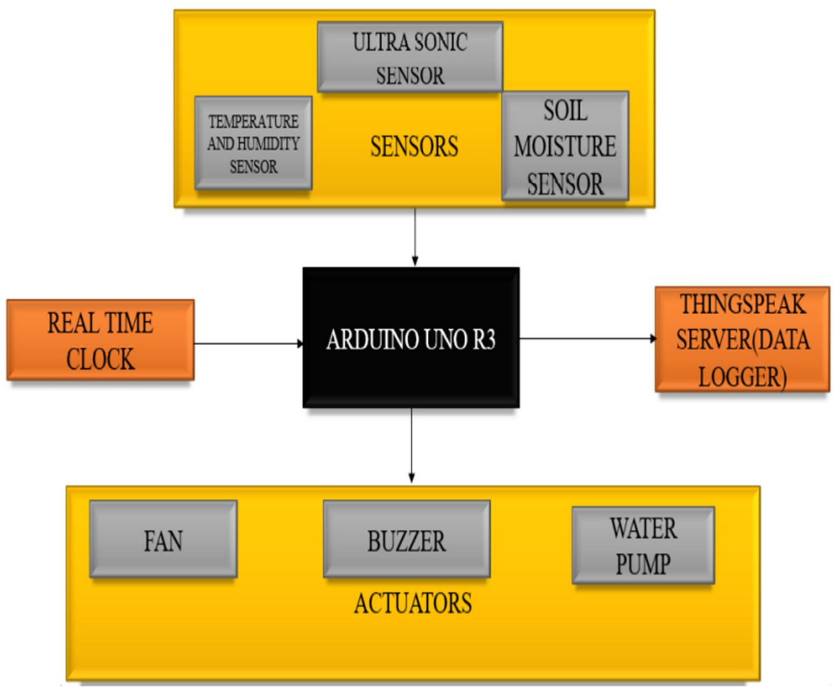

Fig. 1. Block Diagram of the proposed system

Existing systems do not allow for real-time monitoring and controlling at the same time for temperature, humidity, soil moisture level and echo, even if monitoring is available, it requires GSM which requires recharging repeatedly. The proposed system overcomes the above shortcomings by making use of real-time monitoring using Wi-Fi and ThingSpeak which does not require additional costs and controlling is also done during the same process. The Processing is done by the Arduino Uno R3 which acts as the central unit of the system. The three sensors namely DHT11(Temperature and Humidity sensor), Soil moisture sensor and ultra-sonic sensor will detect from the greenhouse and will send the data to the Arduino Uno R3. The real time clock provides the Arduino Uno R3 the reference time and date at which the data is gathered. Then the Arduino Uno R3 will send the data to the Thingspeak server which stores the data, and the data can be accessed at any time on Thingspeak website. Threshold values have been programmed- Temperature- 26º C and Soil moisture-300, when the temperature is above the threshold fan will be turned on and when the soil moisture drops below 300 water pump will be turned on. The buzzer will be turned on every time a spike is detected from the ultra-sonic sensor to scare off any pets nearby. Thus, a continuous cycle of monitoring and controlling is achieved using the same setup.

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B. Flow Charts

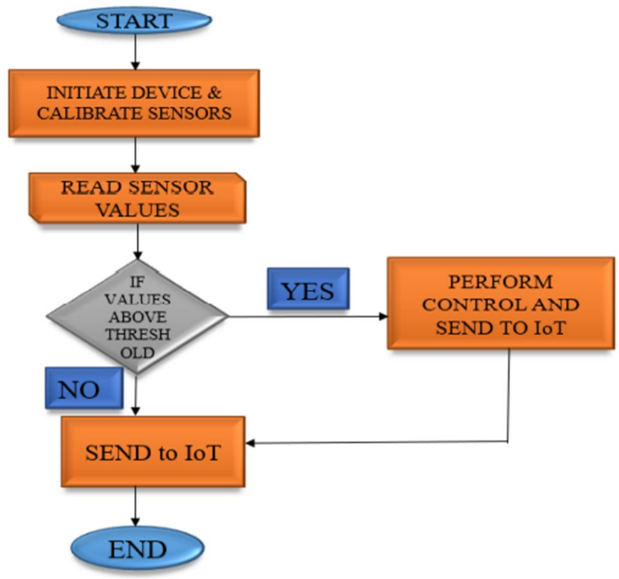

Fig. 2. Flow chart of the proposed system

The flow chart in fig 2 is for the system. The process starts with calibration of the sensors and initiation of the Arduino and other devices in the setup. Then the sensor values are read and sent to the Arduino Uno R3 for processing. The threshold is set as- Temperature - 27º C and Soil moisture- 300. If the temperature value is higher than the threshold then the fan is turned on and if soil moisture drops below the threshold, then the water pump is turned on. The buzzer is turned on every time a spike is detected by the ultra-sonic sensor. After each step the values are sent to ThingSpeak website to display and store, and the process ends. The process is explained in detail in the following.

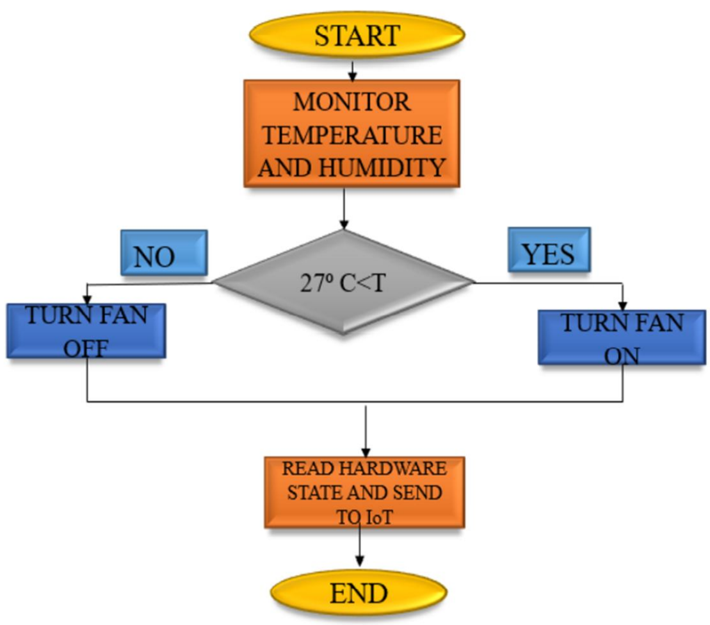

Fig. 3. Flow chart for temperature and humidity

The process starts with the monitoring of temperature and humidity with the help of DHT11 sensor. And then the Arduino checks if the temperature is higher than the threshold value or lower. If higher, the fan is turned on and the value is sent to ThingSpeak server, and the process ends. If lower, the fan is turned off and the value is sent to ThingSpeak server, and the process ends.

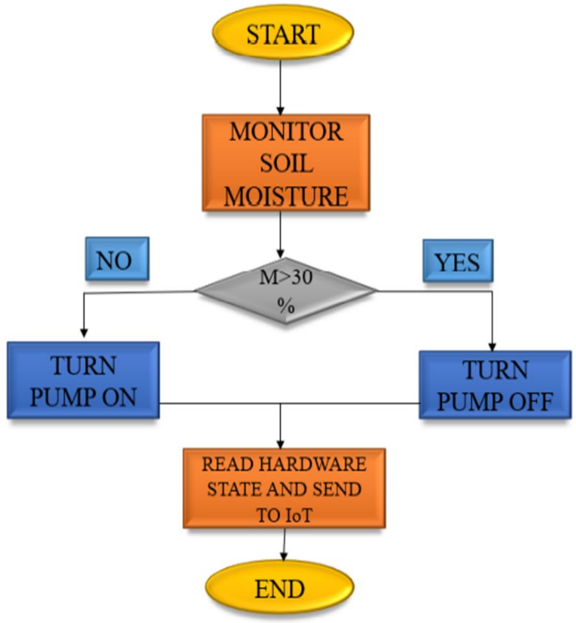

Fig. 4. Flow chart for soil moisture

The process starts by reading the soil moisture with the help of soil moisture sensor. And then the Arduino checks the value against the threshold value which is set at 30% soil moisture or 300. If the value is lesser than the threshold then the water pump is turned on and the value is sent to ThingSpeak server. If the value is higher than the threshold then the pump is turned off and the value is sent to ThingSpeak server.

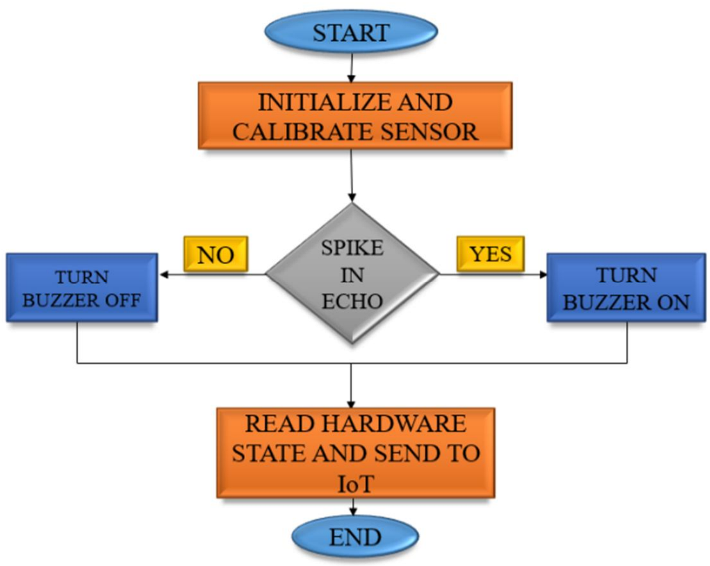

Fig. 5. Flow chart for Ultra-sonic

The process starts with monitoring of the ultra-sonic sensor value and then that value is sent to Arduino. Then the Arduino checks if there's a spike in the value of the sensor. If there is a spike, then the buzzer is turned on and the value is sent to ThingSpeak server, and the process ends. If there is no spike, then the buzzer is turned off and the value is sent to ThingSpeak server, and the process ends.

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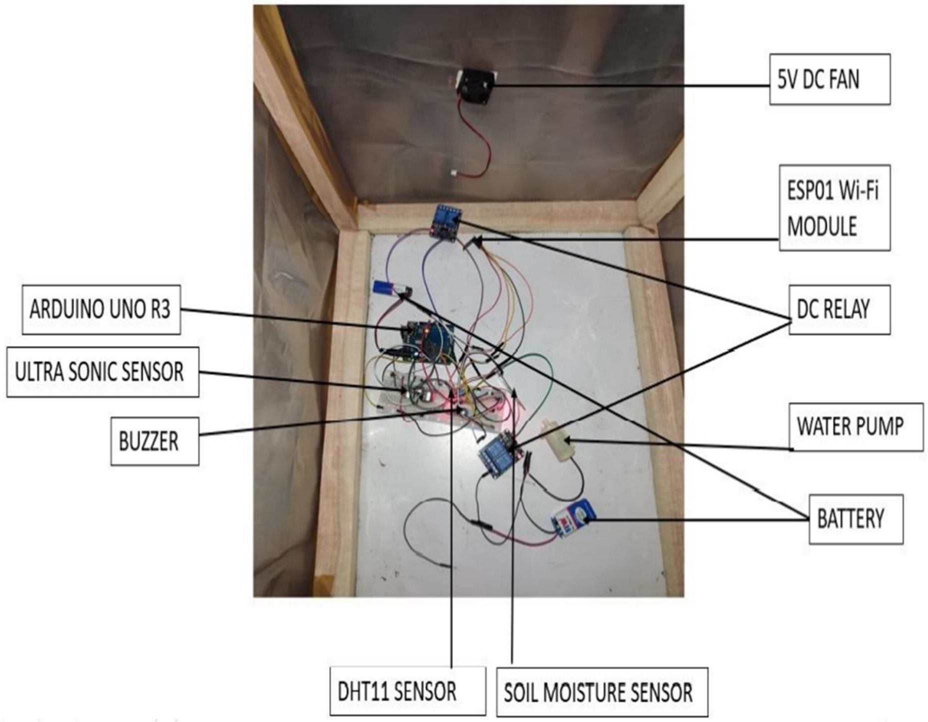
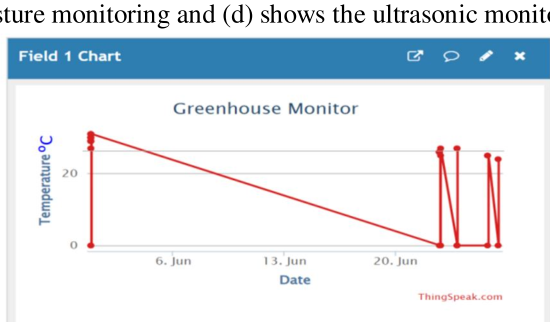


Fig. 6. Circuit diagram of the system

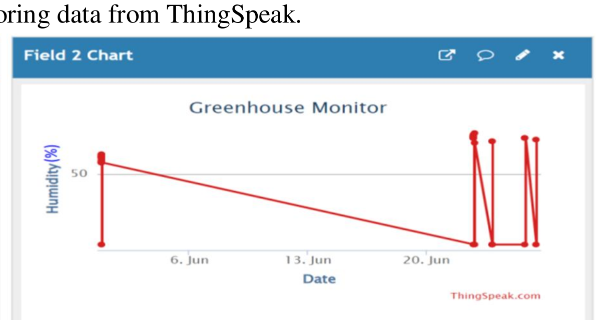
The ESP01 and relay modules takes input of 3.3v and all the sensors will take 5v input, both of which are available in the Arduino. A DHT11 is a basic and ultra-low-cost digital temperature and humidity sensor. It is connected to pin 5 of the Arduino. A Soil Moisture sensor which has two pins to read the soil moisture. It is connected to A0 pin. The Ultra Sonic sensor has two pins and that is used to check echo triggers. The trigger pin is connected to pin 9 and echo pin to pin 8 of the Arduino. An ESP01 Wi-Fi module is also used which enables the circuit to transmit the sensor values for monitoring. The receiver and transmitter are connected to pin 6 & 7 of the Arduino. One battery is used to power the Arduino, and the other two batteries are used to power the fan and the water pump. The Arduino microcontroller is programmed using C programming language using the Arduino Editor. First, sensors are initiated and calibrated, then they will read the parameters, i.e., temperature, humidity, soil moisture level and ultrasonic and will transmit the values to Arduino Uno R3. Then the Arduino will process the data received and will compare the values against the threshold values programmed. If found to be above threshold in the case of temperature and ultrasound and below in the case of soil moisture, the appropriate control measures will be taken. Simultaneously, the data will be transmitted to ThingSpeak using the ESP01 module for monitoring and storage.

IV. EXPERIMENTAL RESULTS

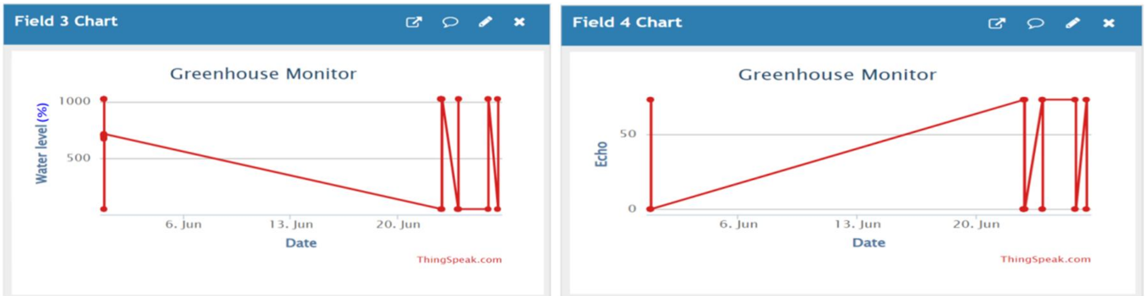
Figures shows the results of monitoring. Figs. 2 (a) shows the temperature monitoring. (b) is the humidity monitoring (c) shows the soil moisture monitoring and (d) shows the ultrasonic monitoring data from ThingSpeak.



(a)



(b)



(c) (d)

Fig. 7. Greenhouse Monitoring in ThingSpeak (a) Temperature (b) Humidity (c) Soil moisture (d) Echo/Ultrasonic

The temperature and humidity readings over a period of 5 weeks is as follows- The inference from the graph in fig. 8(a) is that the average temperature over 5 weeks mentioned above is 26.22º C, and the peak temperature is obtained in week 2(23-05-22 to 30-05-22) at 27.5º, whereas the lowest is 25º C in week 5(13-06-22 to 20-06-22). Fig 6.4 refers to a line graph representing humidity monitored over a period of 5 weeks, from 16-05-22 to 20-06-22. The inference from the graph is the average humidity over 5 weeks is 59.4%, and the peak level of humidity is 65% in week 2(23-05-22 to 30-05-22), whereas the lowest is 55% in week 1(16-05-22 to 23-05-22) and week 4(06-06-22 to 13-06-22). These data are useful as they help understand the ideal growing conditions for the plant in the greenhouse, in this case Amaranthus as the growth of the plant was monitored along the way as well. Fig. 8(b) represents the growth of the plant observed over a period of 5 weeks from 16-05-22 to 20- 06-22. This plant was grown inside the greenhouse and was monitored accordingly. The plant considered here is Amaranthus, this was chosen as Amaranthus is suited for very humid conditions.

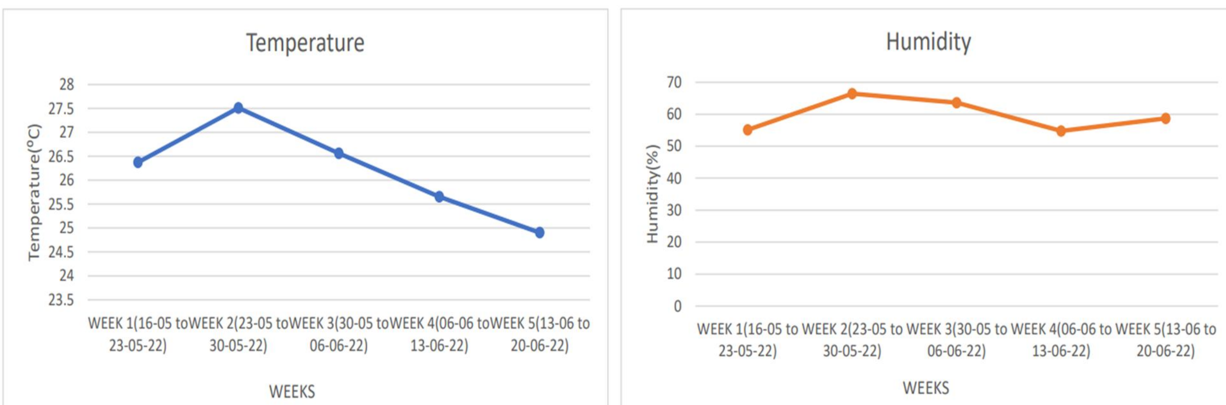


Fig. 8. (a) graph of temperature over 5 weeks (b) graph of humidity over 5 weeks

A. *Case Study of Temperature and Humidity*

1) *Case 1* – When the temperature is less than 27º C In this case the fan will be left off and the values can be seen on the ThingSpeak website.
2) *Case 2*- When the temperature is higher than 27º C In this case, the Arduino recognizes that the temperature has crossed the threshold and it will indicate the relay module to switch on which will in turn the fan on. Hence reducing the temperature to below 27º C again.

Then the temperature is checked again and process repeats.

B. *Case Study of Soil Moisture*

1) *Case 1*- When the soil moisture is above the threshold set at 30% In this case, the water pump is left off and the measured value can be seen on the ThingSpeak website.
2) *Case 2*- When the soil moisture is below 30% In this case, the Arduino will recognize that the soil moisture has dropped below the threshold level and it will indicate the relay module to turn on the water pump which will water the plant for 5 seconds.

Then the sensor reads the value again and the process repeats.

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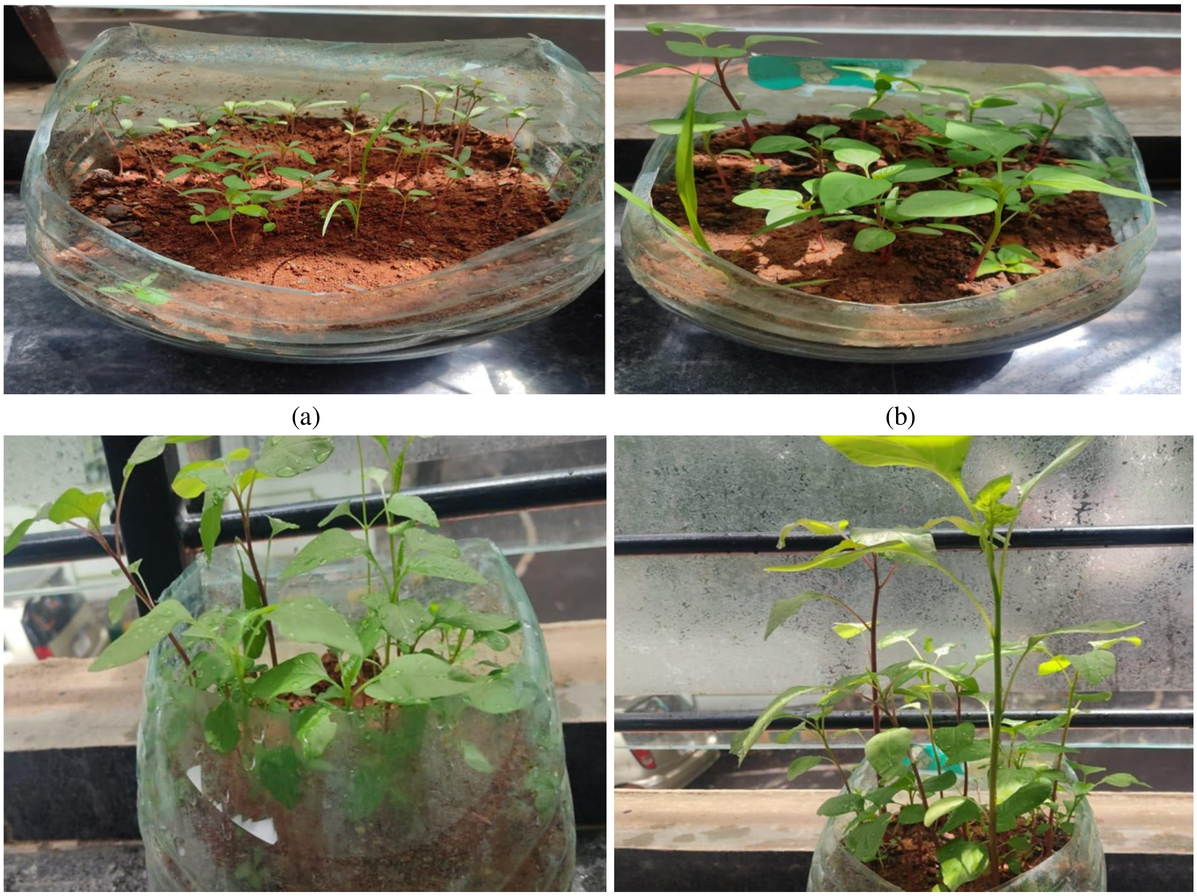
C. Case study for ultrasonic

1) *Case 1*- No spike detected In this case, the buzzer is left off and the measured value can be viewed on the ThingSpeak website.
2) *Case 2*- Spike Detected In this case, the Arduino recognizes the spike in the echo value and will indicate the buzzer to turn on for 5 seconds to scare of any pets nearby.

The value is measured again and the process repeats.

Growth of Amaranthus plant placed in the greenhouse over 4 weeks was observed as follows-



(a) (b)

(c) (d)

Fig. 9. (a) plant growth after week 1 (b) plant growth after week 2 (c) plant growth after week 3 (d) plant growth after week 4

V. CONCLUSION

The greenhouse monitoring and control system was able to monitor the variation in the temperature, humidity light intensity and as well the gas level of the greenhouse. The various sensors were able to trigger an actuator based on the various changes in the environment. This project is to promote convenience and ease of plant growth for small scale farmers. The proposed system will enable small scale farmers to plant healthy crops all year round with little supervision. This system can also be implemented in non-agriculture places such as pots or home gardens which will decrease the need for human intervention with plant growing and encourage people to grow more plants as the effort required decreases.

VI. ACKNOWLEDGMENT

Any achievement, be it scholastic or otherwise does not depend solely on the individual efforts but on the guidance, encouragement and cooperation of intellectuals, elders, and friends. Several personalities, in their own capacities have helped us in carrying this activity.We would take this opportunity to thank them all.

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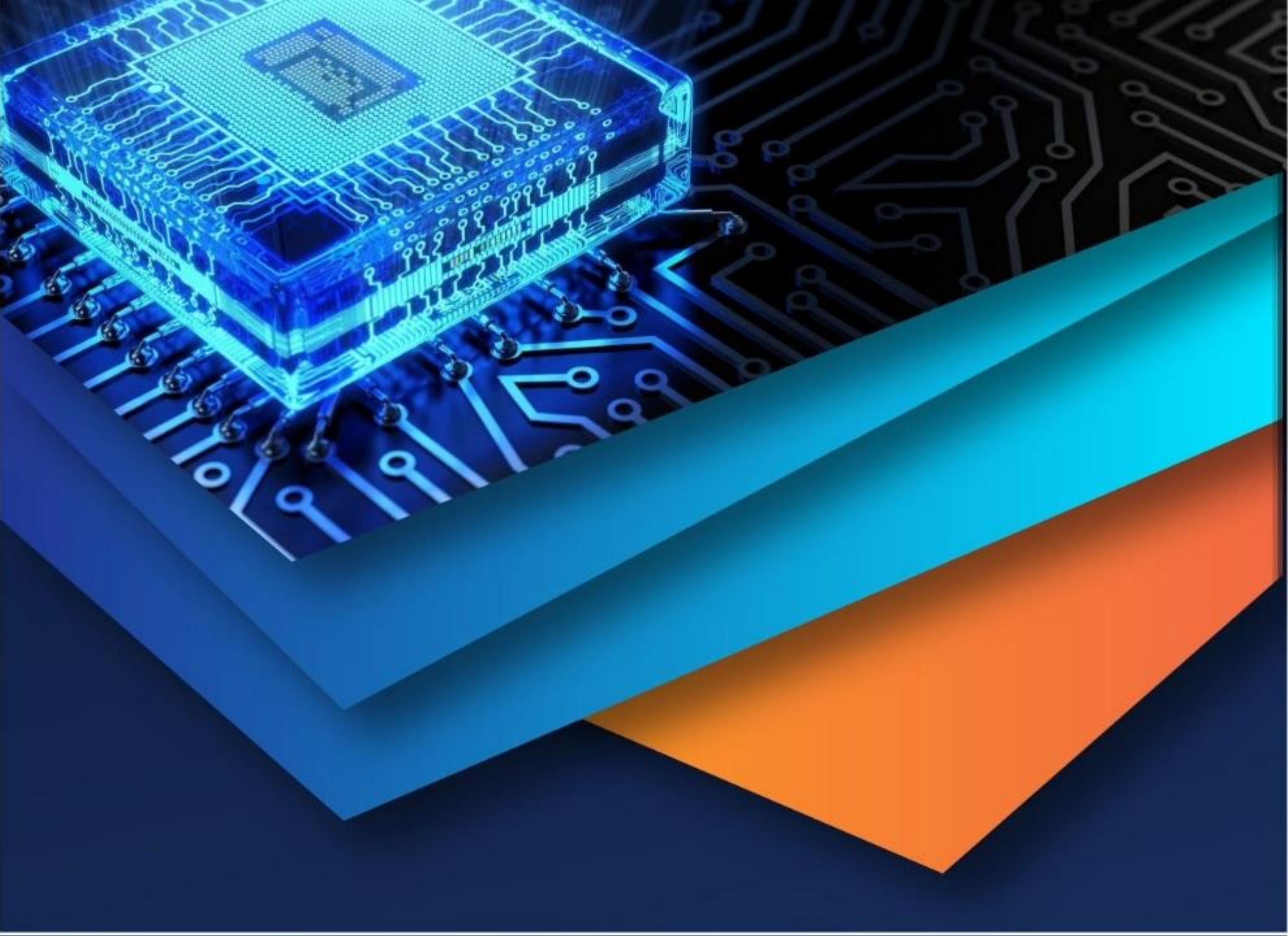

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