Greenhouse Monitoring and Control System with an Arduino System

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GREENHOUSE MONITORING AND CONTROL SYSTEM WITH AN ARDUINO SYSTEM

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Abstract— Agriculture is a major part of our lives as human beings. A lot of research has been carried out in order to be able to develop a monitored and controlled greenhouse system/environment that will help in solving the main problems relating to agriculture which is to enable the increase in the crops being cultivated all year round in the comfort of a small space like the home, and also to reduce human interaction in a small scale greenhouse environment. So accordingly, an automated greenhouse monitoring and control system was proposed for the sole purpose stated above. The methodology used in building the greenhouse monitoring and control system is a wired connection. The system was built using a number of connection wires, sensors, LCD, a cooling system, a power bank, LEDs, LDRs, Arduino board among a few other components. The result obtained was a fully functioning system that was set to monitor the greenhouse environment.

Keywords—Greenhouse, Monitoring and Control, Arduino.

I. INTRODUCTION (*HEADING 1*)

In this time and day, everything can be monitored and controlled automatically. Unfortunately, in an important sector like agriculture, the manual process is still very active, meaning the automatic monitoring and control of a greenhouse system hasn't completely scaled through just yet, especially when it comes to small scale farming.

The reason whereby the automation of a greenhouse system hasn't been put to a full-fledged use may be in view of several reasons, such as the absence of technical know-how, high cost and the requirement of high maintenance.

Agriculture has stood out amongst the most important occupations of individuals since the early advancement of humans and sadly, even to date, manual interventions in farming are inescapable. When it comes to a greenhouse monitor and control system, it is a very important part of agriculture as it can be used to grow plants under a controlled climatic condition for ideal plant produce [1], it is also to a great degree important in the sense that it shields plants from weather extremes by having a controlled climatic environment, it broadens the developing season and also empowers you to sow plants earlier and harvest plants later [2].

In the case of this project, there will be the presence of an automatic greenhouse which will involve the system being closely controlled and monitored in a set climatic condition which is needed for optimum farm/plant produce.

II. ENVIRONMENTAL FACTORS

A. Temperature

According to Asolkar[3], with regards to temperature, he says it is an essential environmental factor that is strongly related to the growth of plants. As a result of this, the control and monitoring of temperature in a greenhouse environment are quite important and this has been made easier to achieve, with the help of greenhouse technologies. In further explanation, it could be explained that plants produce heat as they take in CO_2 and take out oxygen. The heat produced can help in the growth of plants like tomatoes but when there is an excess accumulation of heat produced, without the presence of proper ventilation, it could cause crop diseases. In order to avoid this, temperature controls could be used in bringing the temperature down in order to help in keeping plants at the right temperature for a good harvest[4].

B. Humidity

Humidity: with humidity, plants remove moist oxygen and later on process CO_2 which makes the greenhouse very moist after some time. The dampness could be avoided in order to maximize plant growth by having a proper ventilation system and also possessing great management of a heating system. If these two factors aren't put in place, the greenhouse could harbor diseases, and also, the growth of molds which will cause harm to the plants being cultivated[4]. CO_2 Concentration is an essential nutrient for plant growth[3]. The carbon dioxide is needed for photosynthesis, which is the process whereby plants make their own food. Carbon dioxide is gotten from the air in the atmosphere or from water. During photosynthesis, the plant uses carbon dioxide to produce carbohydrates, which works to promote plant development[4].

C. Sunlight

Sunlight: As regards to plants, some prefer the full sun while some prefer to have a bit of shade. With regard to this information, choosing a specific coverage for your greenhouse will help in regulating the amount of sun it receives[4].

III. REVIEW OF LITERATURES

Ibrahim. A. et al. [5] proposed a system to control and monitoring the environment inside the greenhouse. The system includes local stations and a central station. The local stations measure the environmental parameters and to control the operation of controlled actuators to maintain climate parameters at predefined set points. The system uses the

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ZigBee wireless module servers as the communication link between the local stations and the central station.
Zhou.J [6] introduced a framework that compromises of a data acquisition controller and greenhouse remote monitoring and control software. Both systems require a remote area (central station) for control.
Qiang.G et al.[7] Developed a web-based monitoring and control WSN platform for greenhouse climate monitoring. The system consists of 3 nodes; sink node, wireless sensor node and wireless control node. The wireless sensor node's activity is to collect greenhouse climate information. The operation of the sink node is to analyze and process the information received from each sensor. The responsibility of the control node is to control the climate inside the greenhouse based on the collected greenhouse data.
Rangan. K et al[8] had presented an embedded system which is made to monitor a greenhouse based on these variables which are Humidity, Water pH, Soil wetness, Light intensity and temperature by using sensors which are located at different places, where measured, processed, controlled and updated to owner through SMS using GPS modem.
Daniela. A. et al[9] presents an automated greenhouse system meant for the purpose of making it easier to grow food at home. This system was made in order to analyze if it was possible to use the temperature control system to maintain a certain range of temperatures in order to achieve an increase in the growth of plants. Also, the project checked for the reliability of the watering system, that is, whether or not a perfect soil moisture level can be attained for the plant in question. The final result gotten was that the watering system, sensing of soil moisture (development has to occur for it to be reliable) wasn't fully functional, but the temperature control system was working perfectly, in the sense that there is stability in temperature for the wanted range, for the plant, basil.
Anuradha Gaikwad[10] proposed a system where a ZigBee technology and an Android application is used. Here, the system has a sensor that senses the environment in which the sensed values are sent to the mobile application with the aid of a computer. While using the mobile app, for example, the fan can be turned on by the user. The mobile application here helps in reducing direct supervision by farmers.

IV. System Architecture

The whole purpose of this system is to create an effective greenhouse environment which will drastically reduce the cost of labor and also help small scale farmers cultivate crops all year round.
The system consists of sensors, microcontrollers, and actuators. The system works in such a way that when the environmental parameters cross a safety threshold, the sensors detect a change and the microcontroller reads the data from its input ports and performs the suitable action in order to bring the parameter back to its required level.
The actuators (fan, led, buzzer) are switched on based on the instruction passed to the microcontroller. An LCD is employed to show the condition inside the greenhouse. Lastly, the entire setup becomes user-friendly, easy to put together and quite portable.

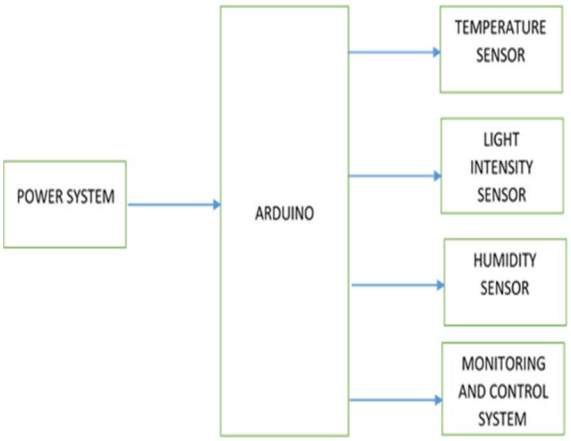

Fig 1: Green House Monitoring and Control System Architecture

A. Functional Requirement of the System

This subsection gives brief information on the set values of the parameters of the tomato crop which is used in this research. These parameters are

1. The user shall set the temperature suitable for a tomato at 27˚C
2. The user shall set the value of Humidity suitable for a tomato at 60%
3. The user shall fix the Light intensity at 80%
4. The user shall set the CO2 level at 400

Furthermore, the set values stated above aid in the control of the greenhouse. An example of this could be explained as follows;
With respect to the temperature, humidity and light intensity, when the temperature passes the set optimum threshold value, the relay will perform the required action which is to either bring the temperature down when it's too high(27˚C) by turning on the cooler and turning the heater on when the temperature is too low. Similarly, when the set value for humidity gets higher than 60%, the heater gets turned on.
Also, with the light intensity fixed at 80%, if the value happens to get higher, the light is turned off which results in a reduction of light intensity in order to avoid the production of bad crops.

B. Programming Language

The programming language used in controlling the microcontroller is C/C++, this language is preferred because it is the language of hardware and it is the main language used in programming the microcontroller (Arduino).

C. Modeling Tools

The system diagram is shown in figure 2.0, the activity diagram used in monitoring temperature, humidity, light intensity, and gas level is shown in Figures 3 to 6. A use case diagram for the greenhouse monitoring control system is shown in figure 7 and the sequence diagram is shown in figure 8.

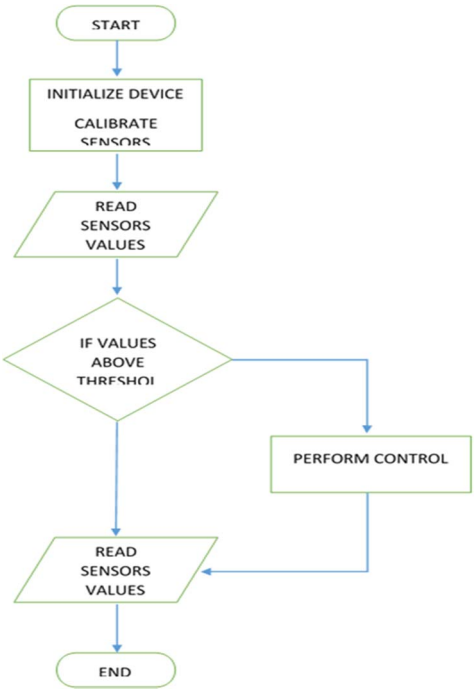

Fig 2: The Greenhouse Monitoring and Control System diagram

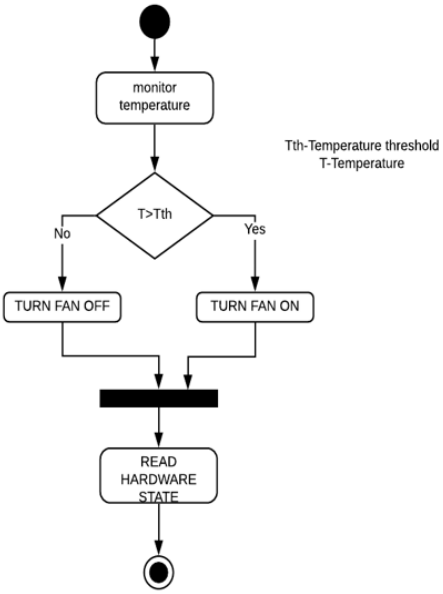

Fig 3: Activity Diagram for Temperature.

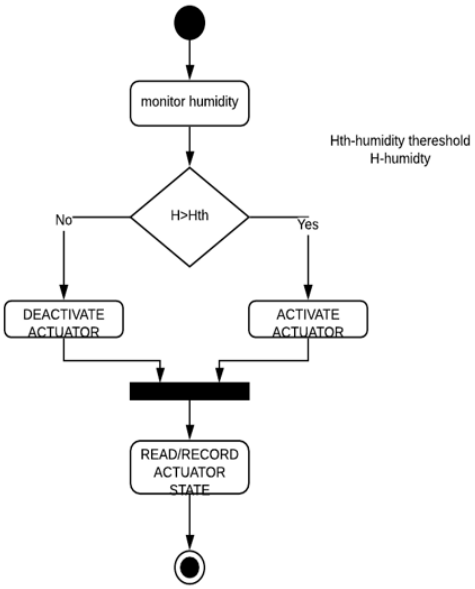

Fig 4: Activity Diagram for Humidity

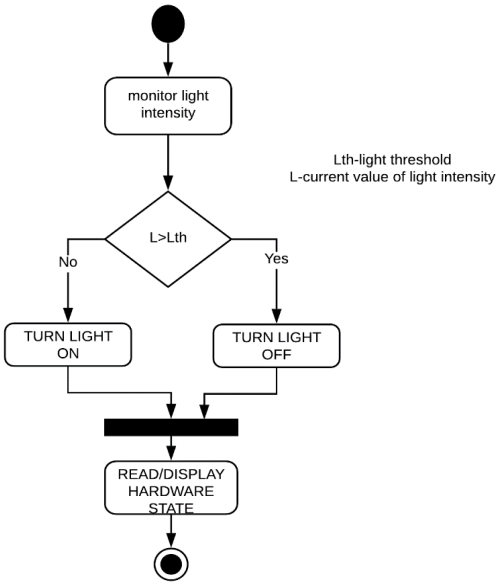

Fig5: Activity Diagram for Light Intensity

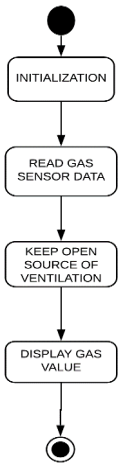

Fig 6: Activity Diagram for Gas

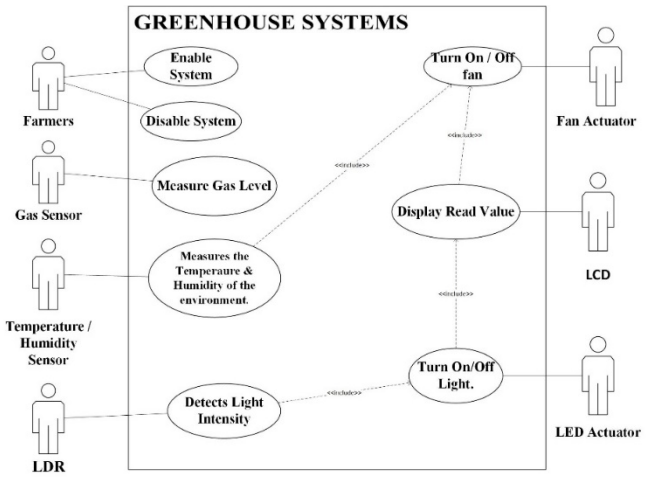

Fig 7: Use Case Diagram for the Greenhouse System

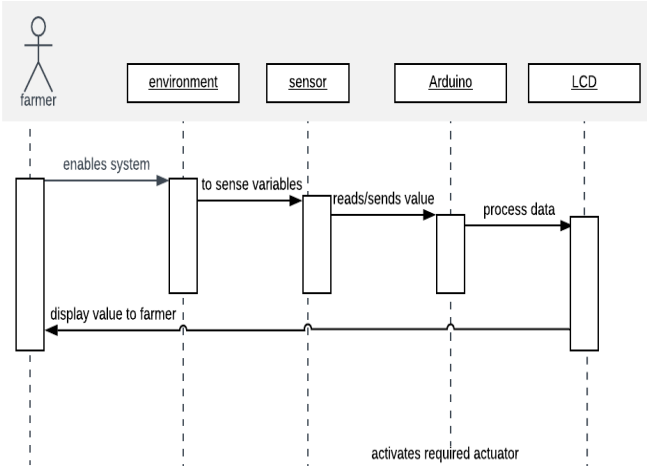

Fig 8: Sequence Diagram for the Greenhouse System

V. HARDWARE REQUIREMENT

In this section, the hardware components used are briefly explained and they are listed as follows:

A. Arduino Microcontroller

Arduino has a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) which runs on the computer and enables it to write and upload the code to the board [11].

B. Liquid Crystal Display (LCD)

LCD (liquid crystal display) is the technology used for displays in a notebook and, other smaller computers[12].

C. Temperature and Humidity Sensor

The sensor used in this project is the DHT22 sensor which is a low-cost sensor used for the measurement of temperature (-40 to 80°C) and humidity (0-100%).
Light Intensity Sensor
A Light Intensity Resistor(LDR) is a component that has a (variable) resistance that changes with the light intensity that falls upon it and LDR is are also called photoresistor. This allows them to be used in light sensing circuits [13].

D. CO2 Sensor

Gas Sensor (MQ2) is used for spotting gas leakage in an environment.

E. Fan

This serves as the coolant for the Greenhouse monitoring and control system.

F. LED

They serve as an indicator of the Greenhouse monitoring control system.

VI. SYSTEM IMPLEMENTATION

In respect to the implementation, the input devices which are the sensors, and the output devices which are the actuators were all connected to the microcontroller in order to be able to monitor and control the greenhouse effect.
In detail, the actuators respond to fluctuations (Increase/decrease of the set threshold for temperature, humidity, light intensity, and CO_2 level) of the environment variables in the greenhouse environment. For example, the fan serves as the actuator for controlling the temperature and humidity level of the greenhouse environment, Light bulb for light intensity and for CO_2.

A. System Setup

The Greenhouse Monitoring and Control System is built using the DHT11. The DHT11 is a basic and ultra-low-cost digital temperature and humidity sensor. The DHT11 uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin. It's fairly simple to use but requires careful timing to grab data. Figure 9.0 shows the connection of the DHT11 to the Arduino.

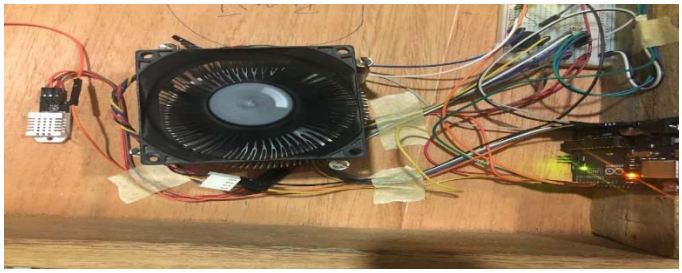

Fig 9: connection of DHT11 with Arduino

The LDR has two pins, to read the light intensity the LDR is connected to the Arduino microcontroller in the form of the voltage regulator. The connection is shown in figure 10.0 below:

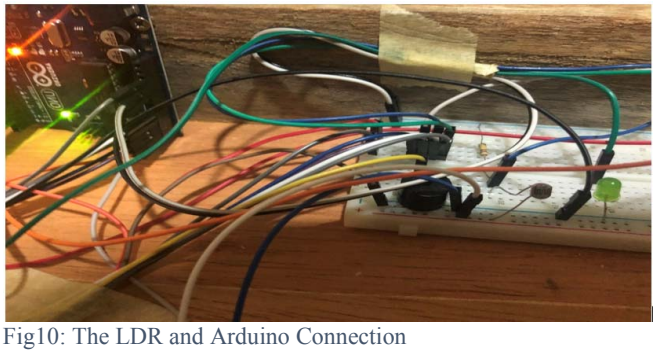

Fig10: The LDR and Arduino Connection

The MQ3 has three pins and that is used in taking the gas level readings of the greenhouse environment. Connection with the microcontroller is shown in figure 11.0 below

Figure 11.0: MQ3 connection with Arduino

B. Greenhouse Monitoring and Control Software Setup

The Arduino microcontroller serves as the brain; it controls the function of the system components. The Arduino microcontroller is programmed using C programming language using the Arduino Editor. The Arduino system setup with other components of the Greenhouse monitoring and control system is shown in figure 12.0:

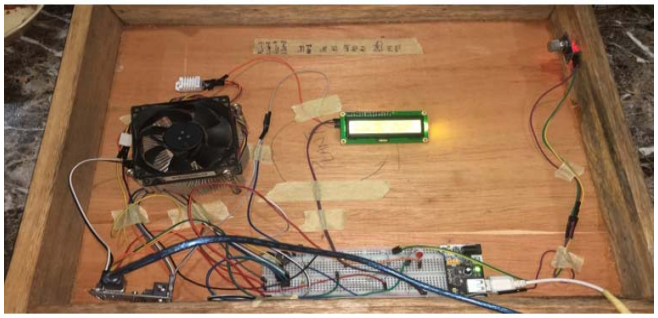

Figure 12.0: Arduino connection with the Microcontroller

VII. SYSTEM TESTING AND RESULT

The physical realization of research was carried out to achieve the conceived idea. The Greenhouse monitoring and control system hardware components were tested.
Unit testing was carried out on the various components of the Greenhouse monitoring and control system. The goal of this testing is to validate that each unit of the Greenhouse monitoring and control system performs as designed.

A. Unit Testing for Temperature and Humidity

The threshold values for both temperature and humidity parameters were changed and there was a drastic effect of the Greenhouse system. For example, when the threshold value for the temperature was set at 32 °C, the temperature reading by the sensor was 28.50°C and as such, the Greenhouse cooling system was turned off. When the threshold value was subsequently changed to 26°C, with this, the
Greenhouse cooling system environment of the greenhouse still at 28.50°C, the fan turned on which is an indication that the environment can no longer sustain the tomato crop. The crop required a very favorable temperature for it to grow.

B. Unit Testing for Gas

Subsequently, a unit test was carried out on the gas level. A lighter was lit and placed very close to the gas sensor and as a result, the gas level went above the threshold value that was set which led to the buzzer going off.

C. Unit Testing on Light Intensity

Lastly, the unit testing was carried out on light intensity. The unit test is in two parts. At first, the light-dependent resistor was shielded from light which led to the decrease in the intensity value below the set threshold value and as a result, the light sensor triggered the led bulb came on. In the second part, when the led bulb was in the on the state, an external light source (torchlight) was introduced to the Greenhouse system. The LDR sensor caused the value of light intensity to go above the set threshold value and as a result of this, the LED went off.

VIII. DISCUSSION

This research was successfully implemented and the goal was to determine how the internet of things can help small scale farmers plant crops all year round in a very conducive environment with very little resources. The research shows that the system when fully deployed can also assist in improving crop production and reducing the involvement of the farmer by self-regulating the necessary input that will promote good farm yield. For the achievement of the development of this system, sensors (temperature, humidity, light sensor, and gas sensor) were incorporated into the system in order to sense the changes that occur in the greenhouse environment. In respect of the sensors, when any of the set parameters goes above the safety threshold, the necessary actuator is then turned on or off. For this system, the Arduino board is the brain of the system where the code is loaded to and controls the actuators. The LCD displays the read values gotten from the sensor readings. A cooling system is present in the system for the purpose of bringing down the temperature of the environment and staying off when the temperature is in the desired range. The systems power source is a power bank. One of the limitations of the implemented Greenhouse monitoring and control system the inability to implement a water system. In future work, a water system will be integrated with the Greenhouse system. A small sprinkler will be integrated and the effect on the Greenhouse system will be noted.

IX. 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 research paper 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.

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