Design and Modeling of Automated Greenhouse Plant Area for Mawlamyine Region (Myanmar)

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***Abstract*—The climate change has brought about unpredictable weather conditions that have resulted in the global food shortage being experienced. A possible solution to this problem is households growing a reasonable percentage of the vegetables and crops in a greenhouse, which does not require too much land space. In the greenhouse, the microclimatic parameters that determine crop yield are continuously displayed and controlled to ensure that an optimum environment is created. The automated greenhouse control system achieves to control of a greenhouse environment by using sensors and actuators which are under the control of a microcontroller running a program. The system is composed of two stations: display station, and the actuators and sensors station. The controller used in the actuators and sensors station, which ensures that the microclimatic parameters stay within pre-defined values as determined and set by the user in the program.The aim of this research is to create an automatic controlled greenhouse system against the climate of Mawlamyine region (Myanmar) that can monitor and control the temperature, soil moisture levels within the enclosed house.**

***Keywords*—automated greenhouse, microclimatic parameters, microcontroller, display station, sensors and actuators stations, Mawlamyine region.**

I. INTRODUCTION

A greenhouse is a structure that provides protection and a controlled environment for raising plan indoors. The primary issue of greenhouse-based horticulture is to manage the greenhouse environment optimally in order to comply with the economic and environment requirements.Food shortage is one of the greatest problems confronting humankind in the 21st century. Global warming and other weather elements have claimed substantial land mass that was available for crops cultivation. In order to address the problem, greenhouse practice which has been in existence for a very long time is now modernized and deployed in many parts of the world.Myanmar is a country where the economy is dependent on agricultural produce. Myanmar weather conditions are characterized by having predominantly long and hot summers, and then, short and mild winters. Such climatic conditions put great strain on the types of crops that could be successfully grown. This is very much true with most horticultural vegetables with medium thermal requirements (tomato, pepper, cucumber, watermelon, marrow, green bean, eggplant).Greenhouses protect crops from too much heat or cold, shield plants from dust storms and help to keep out pests. Temperature control allows greenhouses to become suitable place for growing plants. The cultivation exhibition of plants under controlled conditions. Greenhouses also are often used for growing crops, vegetables, fruits and flowers.

II. RESEARCH OBJECTIVE

The purpose of this research is to demonstrate the working condition of the automatic control system for greenhouse and to protect them from adverse environment conditions.In this proposed design, there are four sections such as sensing unit, control unit, actuator and display unit. Arduino is used as the core control unit. Soil moisture senor and temperature sensor are used for soil moisture content of plant area and greenhouse temperature. Actuators portion consist of water pump, heater (bulb), thermoelectric cooler fan, and then for display unit 20×4 LCD is used.The proposed system has a framework that can gather the sensors data identified with greenhouse environment and yield status and control the greenhouse consequently, in view of the gathered data to foresee and follow up on circumstances for splendidly controlled climatic conditions.The block diagram of greenhouse plant area is shown in Fig.1.

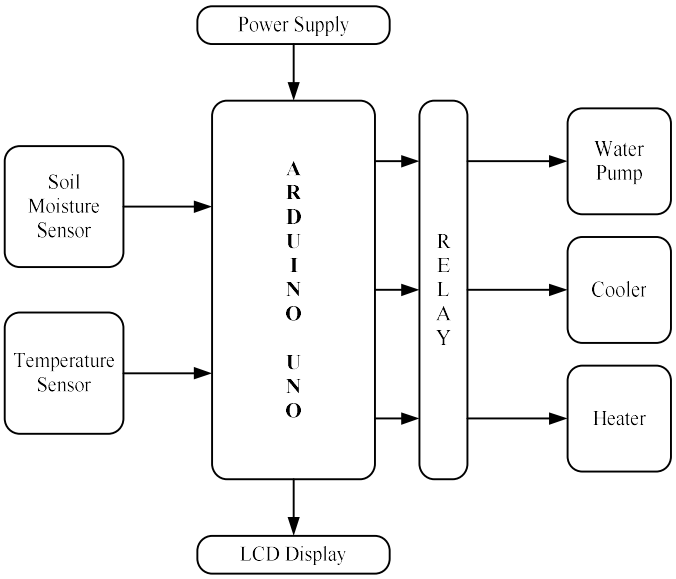


Fig.1Block diagram of greenhouse plant area

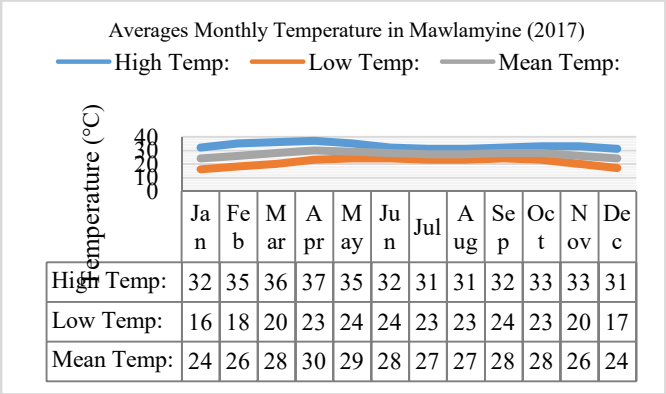
Temperature and soil moisture sensors are used for sensor portion, actuators portion consist of water pump, heater (bulb), thermoelectric cooler fan, and then display for, 20×4 LCD is used. As for the microcontroller, Arduino Uno Board is used. The sensors and actuators station is the heart of the system that is responsible for regulating the greenhouse environment. The sensors acquire the threshold values are need for greenhouse environmental. If any of the sensing variables is over than threshold values, the corresponding actuator will be activated to restore the optimum condition. The Arduino board is programmed with a sequence of codes called a sketch that enables it to read data from sensors that are representative of the greenhouse climatic conditions. Temperature sensor is used for measuring the temperature level in this greenhouse system. When the temperature is lower than predefined level, the heating actuator is activated, and then, the temperature is greater than predefined level, the cooling actuator is activated. The temperature is between the crops will good growing temperature level, these two actuators are deactivated. But the temperature is above 50°C, this temperature sensor does not senses. Soil moisture sensor is used for measuring the moisture content in soil of greenhouse. The soil moisture is lower than predefined content, the water pump is activated. All of these conditions are displayed in LCD. The sensors and actuator devices are important for this development.

III. Data Collection for Greenhouse

In this section, the weather details of Mawlamyine location and growing features of some plants are described. The weather data is collected from hikersbay website and the growing features data of plants is collected by survey from Department of Botany at Mawlamyine University.

A. Weather Details of Mawlamyine Location

Weather in Mawlamyine is influenced by Tropical Monsoonal climate. Rain season is long and dry season is short. There are one or more months with less than 60mm (2.4") of rain. A monthly average temperature is greater than 18°C (64°F). Highest annual temperature occurs just before the rainy season.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Temp:	32	35	36	37	35	32	31	31	32	33	33	31
Low Temp:	16	18	20	23	24	24	23	23	24	23	20	17
Mean Temp:	24	26	28	30	29	28	27	27	28	28	26	24

Fig. 2 Averages Monthly Temperature (°C)

As shown in Fig.2, the hottest month is April, when maximum temperature is about 30°C and the coldest month is December. In this month, temperature could be even 17°C at night. In other months, such as the highest temperature is about 35°C and the lowest temperature is around 20°C.According to the Fig.3, the rainy month have half of the year because Mawlamyine is located directly by the sea. So, the precipitation is higher than other locations. The highest precipitation month is July, it has 50.55 inch and the lowest precipitation month is Feb, Mar and Dec. In these three months, the precipitation is 0 inch.

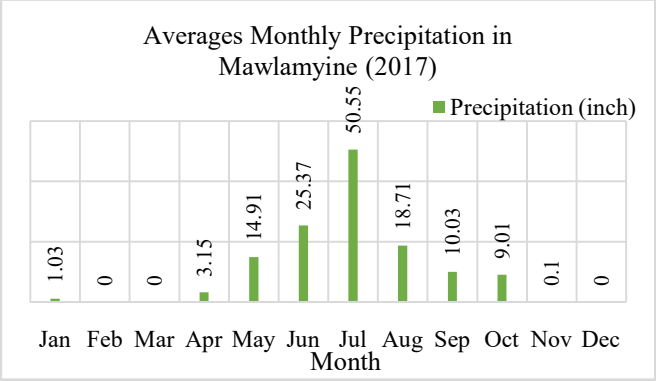


Fig.3Averages Monthly Temperature (°C)

B. Growing Features of Plants

Greenhouses are often used for growing flowers, vegetables, crops and fruits. Greenhouses are very useful, which provide an optimal growing season, allowing sowing plants earlier and harvesting plants later and allows economic crops such as spinaches, lettuces, corianders, strawberries, tomatoes, and cucumbers to crop more successfully. Basic factors affecting plant growth such as water content in soil and temperature. The growing features of some plants are illustrated in Table I.

TABLE I

GROWING FEATURES OF SOME PLANTS

Name of Plant	Watering	Temperature
Spinach	Regularly	>15°C
Lettuce	Regularly	16°C ~ 18°C
Coriander	Regularly	> 30°C
Strawberry	Adequately	>15°C
Tomato	Regularly	18°C ~ 29°C
Cucumber	Regularly	>30°C
Culantro	Regularly	25°C ~ 30°C

IV. System Design

A. Circuit Diagram of Greenhouse System

The complete circuit diagram of greenhouse system is shown in Fig.4.The red lines are power supply, the black lines are ground and the blue lines are signal. Then, the pump and heater (bulb) are connected with AC 220V and the cooler is

connected with DC 12V power supply. The pin connections of temperature sensor, soil moisture sensor, liquid crystal display and relay with microcontroller (Arduino) are shown in this proposed circuit design.

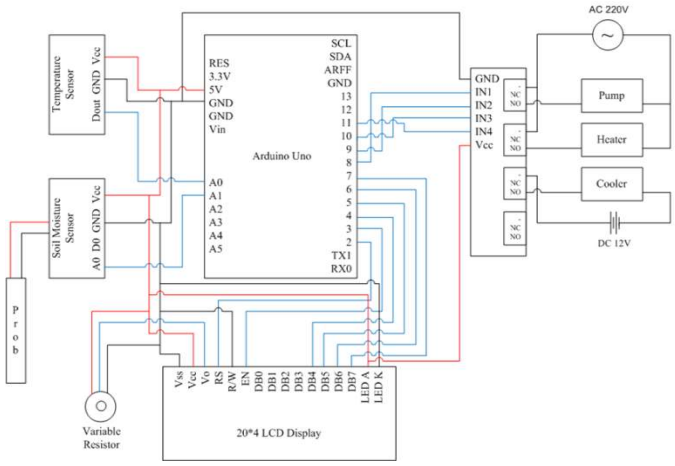


Fig. 4Circuit diagram for greenhouse plant area control system

B. *System Operation Flowchart*

The control strategy for the system in this work is two main processes. The temperature control requires the definition of two threshold limits: upper limit and lower limit. When the temperature is exceeded the upper limit, thermoelectric cooler fan is activated to cool the greenhouse environment and when the temperature drops below the lower limit, the thermoelectric cooler fan is deactivated while a heater (bulb) is activated and vice-versa.

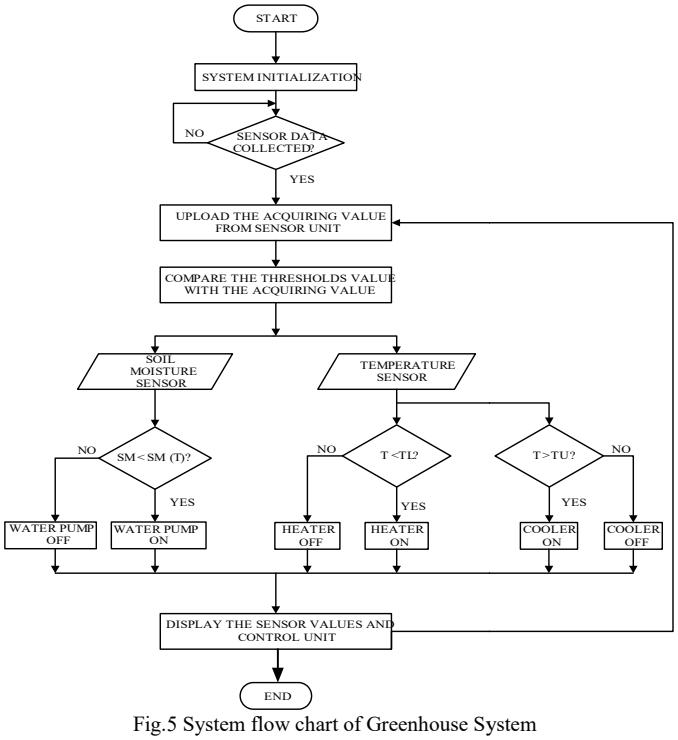


Fig.5 System flow chart of Greenhouse System

The moisture control is defined by a threshold, which ensures that, if the soil moisture content falls below the set value, water pump is activated, and then deactivated when optimum condition is restored.

Firstly, the system starts with the collected data from each sensor, which is relative to the continuously incoming data. If the sensors are not collecting their relative data, this condition is returned. Then, sensor uploads these values into sensing and response unit to comparing with acquiring values. If the set of soil moisture measure greater than the acquired soil moisture measure, the Arduino commands to turn on the water pump, else turn off the water pump. If the lower set temperature greater than the acquiring temperature, the Arduino commands to turn on the heater (bulb), else turn off the heater (bulb). When the upper limit of temperature is greater than the acquiring temperature, the Arduino commands to turn on the cooler, else turn off the cooler. To inform the status of the system, the LCD displays the soil moisture content value, the temperature value and state of the control units.The system is clarified using the flowchart that is illustrated in Fig.5.

V. TEST RESULTS

A. *Prototype Design of Greenhouse*

By inspiring the freestanding greenhouse, this prototype of greenhouse is developed. Freestanding greenhouses have separate structures; it can be set apart from other buildings to get more sun and can be made as large or small as desired, separate heating system is needed, electricity and water must be installed. This design of greenhouse is the rectangle shape, and frames made with fiber plastic.Display and thermoelectric cooler are installed in front of the greenhouse, and microcontroller (Arduino) and relay are installed inside of the greenhouse. Sensors and actuators device such as temperature, soil moisture sensor, cooler fan, heater and drop water line are also placed inside of the prototype frame. The prototype greenhouseis shown in Fig.6.

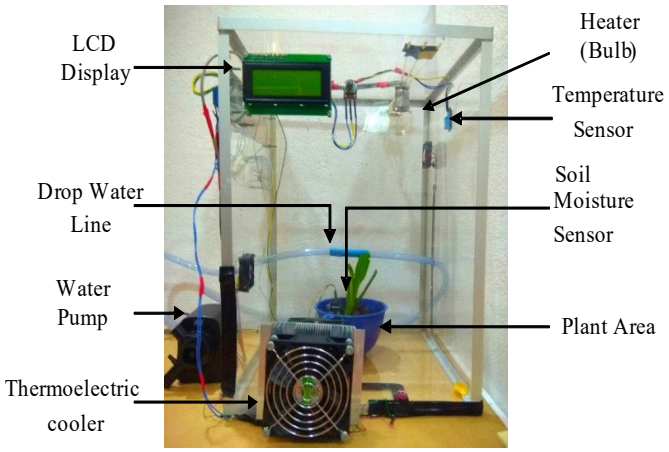


Fig.6 Prototype of greenhouse design

B. Testing Results

In this section, we test two processes for soil moisture and temperature control. For soil moisture control, the soil moisture sensor tracks the level of water in soil.When the water level recorded a higher percentage than 10%, the pump is turned off. Display for this condition is shown in Fig.7.

Fig.7. Displaying the sensor value and actuators state inLCD

While the level of water is lower percentage than 10%, water pump is turned on as shown in Fig.8.

Fig.8. Display for moisture decreasing in soil

In the process of temperature control, when the temperature is greater than 30°C in the greenhouse environment, thermoelectric cooler fan is turned on to cool the greenhouse environment as shown in Fig.9.

Fig.9. Temperature increasing in greenhouse

When the temperature goes less than 25°C in the greenhouse environment, a heater is turned on as shown in Fig.10. When the greenhouse temperature is between the 25°C and 30°C, the system is stable, and any actuators are not response.

Fig.10. Temperature decreasing in greenhouse

C. Temperature Changing Result

The two graphs show the temperature changing result when the cooler or heater is turn on. These results are testing when the room temperature at 27°C condition. The timing graph of temperature changing will be different when the room temperature is different. Fig11shows the temperature changing result when the heater actuator is turn on and Fig.12shows the temperature changing result when the cooler actuator is turn on.

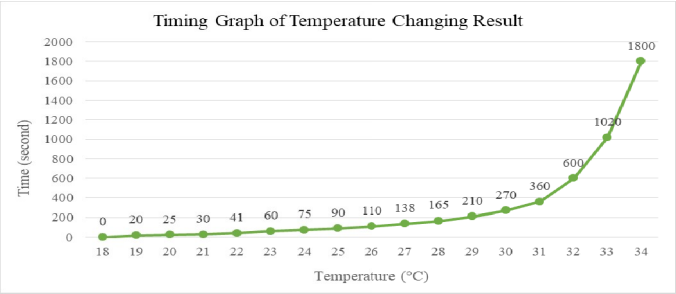


Fig.11. Temperature changing result of heating condition

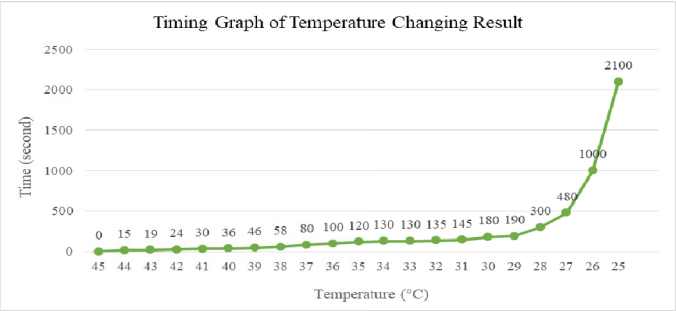


Fig.12. Temperature changing result of cooling condition

VI. CONCLUSION

In this research, the automated greenhouse control system that has been successfully designed and built to protect seedlings in nurseries from intruders, and also grow them to maturity should the need arise using a very small area of land. This system produces healthier crops since pests are usually kept away from the greenhouse enclosure. The system's reaction time to restoration of variations of microclimatic parameters suffers from a few seconds delay because of the program scan cycle and the electro-mechanical relays used. The system is fully automated as it does not require any form of adjustment from the user.

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