Remotely Controlled Automated Greenhouse System

Abhijit Krishna Menon , Akshay Rajeive Krishnan , Pothigai Selvan A , and T.S Rajalakshmi

Abstract—The Remotely Controlled Automated Greenhouse System aims to counter the problem that most tier 1 and tier 2 city households have to face when they decide to have and maintain plants at home. The problem being that of, the lack of time to care for the plants. The system's features such as temperature and humidity control, automated watering system and continuous update delivery definitely helps reduce the need of an individual constantly watching over the growth of the plant. The user can remotely access the data, and also control the device from a remote location using a web interface that gives him control over the various sensors and actuators that are a part of the system. The project also implements a Hydroponic system for water and nutrient delivery to the plants which help in the saving of water upto 70% as opposed to the traditional soil based delivery.

Index Terms—Mechatronics, Automation, Greenhouse, Hydroponics, Raspberry Pi, Remote Control.

1 Introduction

A Greenhouse is a structure or building where plants are grown. Greenhouses vary in size from small sheds to large industry-sized structure. Miniature greenhouses are known as cold frames. Greenhouses can be made using many different materials. The most popular are polythene or glass, and it's also possible to find greenhouses made of plastic. Greenhouses favor planting because they create favorable conditions for plants to grow. Plants grown in greenhouses absorb sunlight through the transparent greenhouse roofs. The sunlight heats the interior of the greenhouse and as a result, it retains heat for a long time. This creates a perfect environment for plants to thrive.

It has been estimated that the global population will expand by 3 billion by 2050, and that 80% of the Earth's population will live in urban centers. With these statistics it will require an area about 20% more than that of Brazil to grow enough food to feed them if traditional farming practices continue as they are today. This is not even mentioning the part where a lot of major cities are running quick and out of water. The most prominent example being Cape Town in South Africa where the water is forecast to completely run out by April 2018. With the need for food farming rising and the water supply falling consistently it is clear that a solution needs to be found to be able to cater to both these evolving truths.

The 'Remotely Controlled Automated Greenhouse System' aims to counter the problem that most tier 1 and tier 2 city households have to face when they decide to have and maintain plants at home. The problem being that of lack of time to care for the plants and the inadequacy of city infrastructure to accommodate traditional gardens. Our project aims at addressing these issues by automating the processes involved in growing a garden while also enabling users to grow vegetables at home. The device provides an artificial environment for the plants to thrive while also implementing a hydroponic based watering and nutrition system that reduces water consumption by up to 92 percent. The system's features such as temperature and humidity control, automated watering system along with a supply of the plant's nutrient requirement and continuous update delivery definitely helps reduce the need of an individual to constantly watch over the growth of the plant. Other features of the project include:

1) An application for the user end so as to enable to remotely access the data, and also control the device from a remote location using a web interface that gives him control over the various sensors and actuators that are a part of the system.

2)Module wise design of the unit making it easy to dismantle, hence portable and convenient for the user.

3)A retractable roof system to allow natural light to come in when necessary.

4)A temperature sensor to detect the temperature and actuate the cooling fan accordingly.

5)An automated Watering System that implements a Hydroponic system for water and nutrient delivery to the plants which help in saving up to 90 percent of water as opposed to the traditional soil based delivery.

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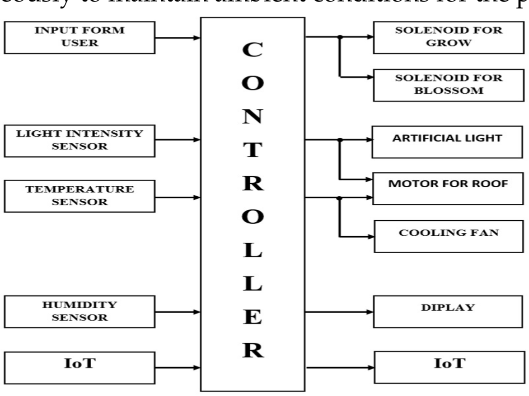
1.1 Hydroponics

Hydroponics, by definition, is a method of growing plants in a water based, nutrient rich solution. Hydroponics does not use soil, instead the plant comes directly in contact with the nutrient rich water solution. Hydroponics possesses several advantages over a soil medium. Unlike plants grown in soil, plants grown in a hydroponics system do not need to

develop extensive root structures to search for nutrients. It is easier to test and adjust pH levels. In the hydroponics method, plants are raised in an inert and perfectly pH balanced growing medium where the plants only need to expend minimal energy to acquire nutrients from the roots. The energy saved by the roots is better spent on fruit and flower production. Hydroponics is suitable for commercial food producers and hobbyist gardeners alike. Almost all plants except the ones that take up too much space like watermelons or squashes, and the ones that grow below the ground like potatoes and carrots can be grown in the hydroponic greenhouse system. The plants that are usually grown commercially include -
1)Strawberries
2)Mint
3)Tomato
4)Thyme
5)Coriander
6)Cucumber
There are nutrient mixes that are readily available called Grow, Green and Bloom that just need to be added to the water. They contain varying levels of micro and macro nutrients that are necessary for the plant during its various stages. These nutrient mixes are added direct to the water to provide nutrition to the plants.

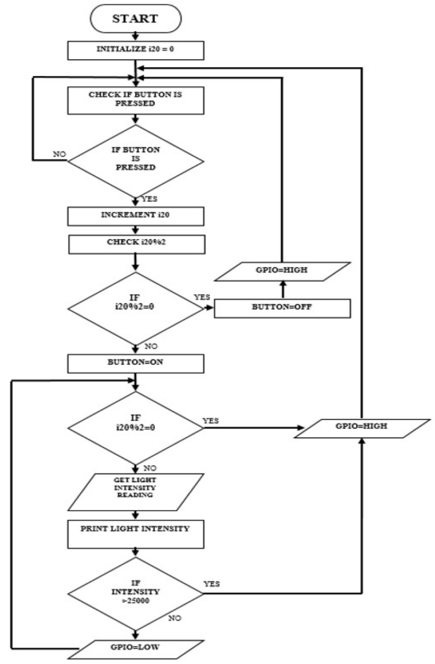
2 METHADOLOGY

The device consists primarily of 3 subsystems running simultaneously to maintain ambient conditions for the plants.



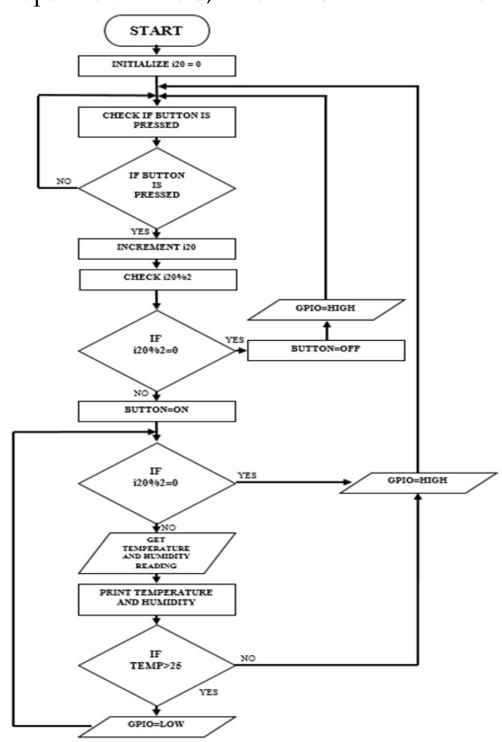
2.1 Light Sensor with Roof

When the light intensity is low, the roof will open up if it occurs during the daytime. If the light intensity is low during the evening hours, our LED grow lights will turn on. These LEDs can also be turned on and off manually through the GUI buttons. The roof can also be opened by the user when he wishes by using the roof open and close button. Another button to clear all the logs on the GUI is used to clear the screen of any data.



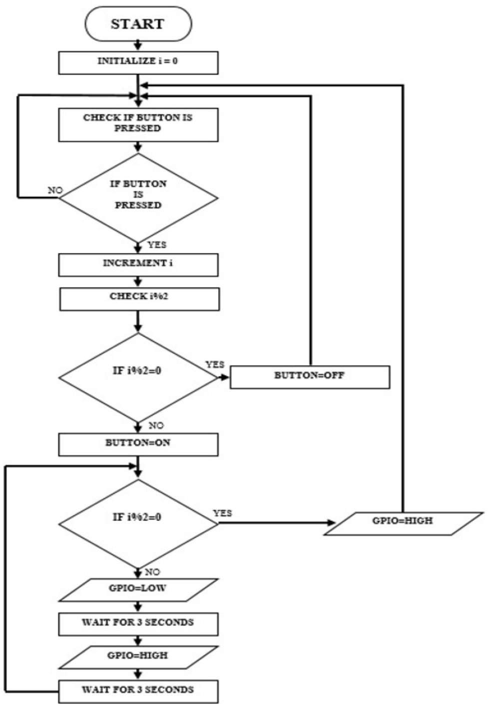
2.2 Temperature and Humidity Sensor Along With the Fan

To get the temperature sensor running in the background, click on the temperature sensor button to trigger it. The temperature sensor will run and give you a temperature and humidity reading at intervals with a time-stamp alongside. And if the ambient temperature crosses the set threshold (here it is 25C), the cooling fans will automatically turn on. Once the temperature drops below 25C, the fans will turn off.



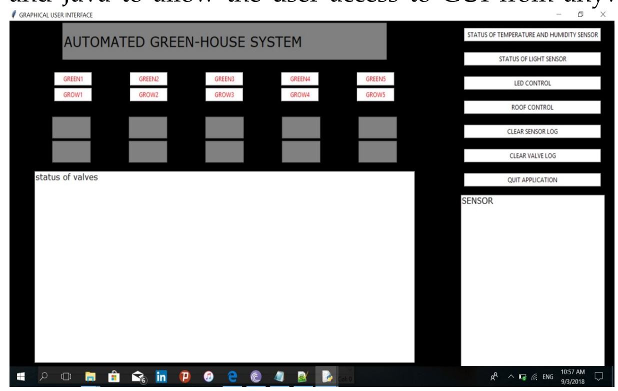
2.3 Green and Grow Valve Algorithm

Using the GUI the user may choose whether the pots must receive the Green solution or the Grow solution. The return pipes must be fitted to the respective tanks. Now the plants will begin to receive their respective solutions in a 3 minute off and a 3 second on cycle. Clicking on the valve buttons again will turn the valves off.



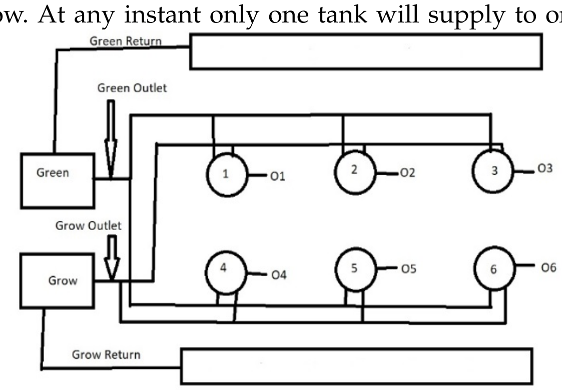
2.4 Graphical User Interface (GUI)

The graphical user interface (GUI) is used for the user to interact with the project. Various commands such as requesting for temperature control and a display of the temperature. Switching the LED strips on/off. Controlling the opening and the closing of the roof. Controlling the solenoid valves according to which plant requires which nutrition. Firstly the user needs to connect to the Raspberry Pi micro controller via a WiFi network. This connection must be stable in order for the GUI to function. Once it is connected the user can start up the GUI. Here corresponding to the plants the user has chosen to put into the pots, he will need to supply either the grow solution or the bloom solution. This must be done by the user for each pot with the plants in order for them to receive the nutrients and water.Next once the light sensor button is clicked, it switches on the light sensor. There a specific threshold set to this LDR based on the requirements of the plants. If the light is insufficient, one of 2 things will happen, if it is in the day hours, the roof will open, otherwise the artificial lights will turn on. Similarly when we press the button for the humidity and temperature sensor, the sensor is turned on and keeps sending the temperature and humidity readings in the background. If the temperature should go above the set threshold, the roof opens up if it is during the night, else the cooling fans are turned on until the temperature drops below the set value. A way to control and vary humidity was also envisioned but not applied due to money and time constraints. Using a humidifier or water sprayers we could have varied the humidity as well. Although this would be very expensive and difficult to control in a small space. One of the main limitations for this model is that the user and the micro controller must be connected to the same local network. For future enhancements we could create a web application using PHP and Java to allow the user access to GUI from anywhere.



2.5 Piping Circuitry

To accommodate a greater variety of plants grown, changes in the piping circuitry had to be made in order to provide different nutrients to each plant. One solution would be to use a neutralizing medium such as an ion exchange resin to neutralize the water returning to the tank. This although is also not a cost saver and would require regular maintenance. Our final solution resulted in using two separate piping circuits along with two different tanks containing the required nutrients in the water. Two tanks are employed one green and the other one grow. Both the tanks have separate outlet piping and through the solenoid valves have outlets into all the 6 pots. Each pot has an return outlet connected to whichever tank is being initiated for that pot, that is either to the green or to the grow. At any instant only one tank will supply to one pot.



2.6 Integration of Subsystems

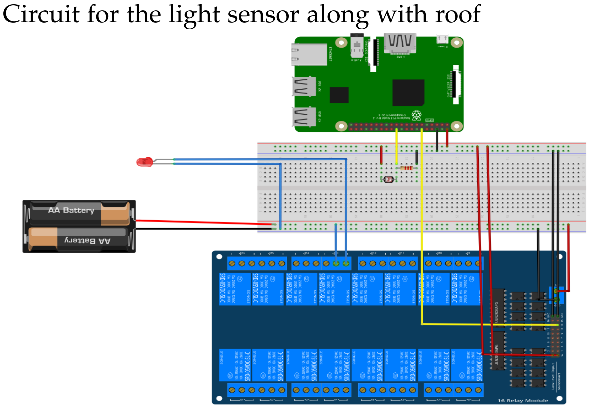
The graphic user interface acts as a connecting bridge between the user and the device. The user can choose to enable the various valves available or decide to have the temperature sensor up and running. The temperature sensor runs continuously in the background, thus turning the fan on and off as per requirement. The same applies for the light sensor and the LED lights. The user also determines when the roof is open or closed depending on whether it's day or night.

3 Conclusions and Future Enhancements

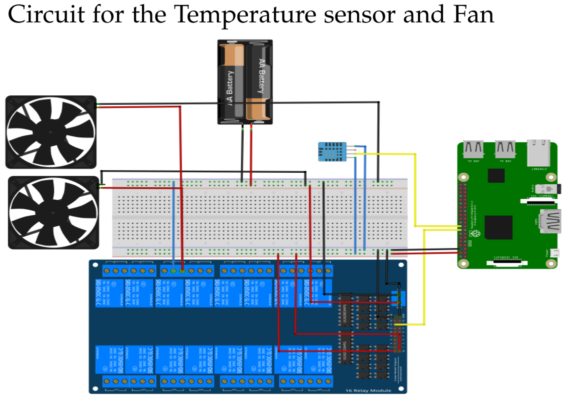
We wholeheartedly believe that there is a lot of scope for this project in the future if implemented properly. This project is built for the purposes of people living in urban households that do not have time to take care of plants and maintain them. The future that we as the makers of the project see for it are -:
1) Increase capacity of the number of plants.
2)Implement Machine Learning to determine when the plants have issues such as pests or if the plant is not growing properly.
3)If there was more funding, additional sensors such as pH level, EC level etc.
4)If there was more funding, additional devices such as a condenser, humidifier etc. could be added to make it more efficient.
5)Artificial Intelligence could be implemented to set requirements of the plants automatically by sensing internal and external condition without human interference.
6)A web/mobile application can be developed to avoid the usage of a Python GUI.

Appendix A
Circuits

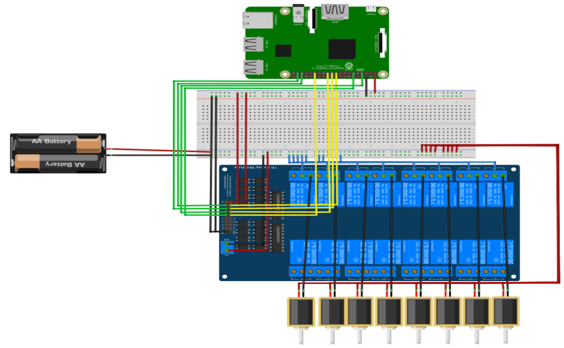
Circuit for the light sensor along with roof



Circuit for the Temperature sensor and Fan



Circuit for the valves working along with the Graphical User Interface



Acknowledgments

The successful completion of this project would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

Special thanks should be given to Ms.T.S.Rajalakshmi, our project supervisor and guide for her professional guidance and valuable support. We would also like to thank the panel members for their support and helpful inputs that helped shape the project.

We would like to thank the Head of the Department Dr.G.Murali for his insightful comments and encouragement.

References

[1] Liu Dan, Cao Xin and Huang Chongwei, *Intelligent Agriculture Greenhouse Environment Monitoring System Based on IOT Technology*. Intelligent Transportation, Big Data and Smart City (ICITBS), International Conference on 19-20 December 2015).
[2] Venkata Naga and Rohit Gunturi, *Micro Controller Based Automatic Plant Irrigation System*. Journal of Advancements in Research Technology, Volume 2, Issue 4, April-2013.
[3] Seisuke Kimura and Neelima Sinha, *How to grow tomatoes*. Article in Cold Spring Harbor Protocols, November 2008
[4] Yunseop Kim, Robert G. Evans and William M. Iversen, *Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network*. IEEE Transactions on Instrumentation and Measurement Volume: 57, Issue: 7, July 2008.
[5] S. V. Devika, Sk. Khamuruddeen, Sk. Khamurunnisa, Jayanth Thota and Khalesha Shaik, *Arduino Based Automatic Plant Watering System*. International Journal of Advanced Research in Computer Science and Software Engineering.
[6] Electronics Hub - *https://www.electronicshub.org/*
Mint Growing by Doug Hocking
https://www.dpi.nsw.gov.au/agriculture/horticulture/vegetables/commodity-growing-guides/mint-growing
[7] Temperature Control
http://homeguides.sfgate.com/methods-decrease-temperature-greenhouse-21620.html
H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.