SMART SOLAR GREENHOUSE BASED PLDC

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Abstract- Climate change, diminishing resources, and a growing population are putting a tremendous strain on the global farming economy. It is envisaged that growers will be seeking for new ways to boost production efficiency and crop resilience in these conditions. Smart greenhouses are an excellent illustration of how the Internet of Things (IoT) is becoming more prevalent in agriculture than ever before. In a smart greenhouse, the temperature, humidity, and light levels may be precisely regulated to meet the demands of each plant. In the past, microclimate and agronomic factors were documented in a very manual and inconsistent manner. What can be quantified is limited, and farming is carried out on a pre-determined, speculative timetable. The greenhouse's climate is continuously changing and can harm crops because of the effects of the weather and other factors like open doors or illnesses in the early stages.

It is critical to maintain controlled lighting and temperature within a greenhouse environment. Plants can be damaged or killed in a matter of hours due to changes in lighting and temperature. In greenhouses, remote monitoring devices can safeguard expensive plants from excessive temperature fluctuations or poor lighting.

Keywords- Smart; greenhouse; solar; PDLC; sensors.

1. Introduction

Plants grown in controlled environments have been around since the Romans. The 17th century saw the advent of sophisticated greenhouses throughout Europe. Plants from tropical regions were imported and studied in these private greenhouses [1]. It was difficult to keep the greenhouses warm and ventilated. Greenhouses got more efficient and practical as building materials and building processes developed. Greenhouses have become increasingly cost-effective and energy-efficient in this century, with many now being found in backyards, gardens, and even balconies of homeowners. Most greenhouses nowadays are still constructed with polyethylene sheeting, aluminum extrusions, PVC water pipes, and galvanized steel tubing as the primary building materials.

Traditionally, humans had to work in the greenhouse to see all the essential levels physically. The conventional technique is slow and requires a lot of energy. This research [2] focuses on developing a framework that can screen and anticipate variations in light, temperature, soil moisture, and humidity levels in the greenhouse. The survey's focus is to develop a controlled monitoring framework for observing different parameters using sensors and sending email and SMS alerts. The proposed framework comprises an estimation for light, temperature, soil moisture, and humidity. The system also alerted farmers about potential changes in the conservatory so that precautions could be made. This study used a few experiments to illustrate the framework's usefulness. Tests have shown that the framework is reliable in disseminating information directly to farmers.

A fully automated urban greenhouse (AUG) would be impossible without a sophisticated network of sensors. As part of their graduation project, the authors of this paper [3] discuss the design methodology they used to create a prototype for an intelligent network of sensors. In order to monitor lighting, temperature, water level, and ventilation, this network of smart sensors connects with the AUG's sensing, power, and automation components, as well as its visualization and user interface components. They used an electric box to cover the temperature, light, and humidity sensors. They also used a Raspberry Pi for processing data along with Arduino boards for controlling the sensors. To visualize and track the readings of different sensors, a webpage was created.

The study in [4] aims to create a smart system to control blending of colors utilizing LED lights in a greenhouse. The testbed's hardware components for providing the appropriate light requirements for optimal growth of plants in a greenhouse are explained. A straightforward system for plant growing with monitoring and control using IoT is offered. To verify the above properties, a feedback mechanism for lighting control is devised to obtain the required photosynthetic photon flux density (PPFD). In the testbed, microgreen kale was allowed to grow for two weeks and was reaped after the experiment duration. The results showed that the micro-green kale thrived well in the intended testbed and lighting conditions. In the study in [5], fuzzy logic was used to analyze greenhouse data obtained from 18 sensor nodes over the period from December 2017 to April 2018. There was an option to regulate the greenhouse remotely. They monitor temperature and humidity for starting functions of the heater, cooler, or irrigation, however, no lighting control is done. Also, a PC is running all the time to perform the fuzzy logic to determine the required action, this can be inefficient from the energy point of view and costly at the same time. The research in [6] proposed monitoring and control of a greenhouse system, where various types of sensors work together to control several parameters including soil moisture, lighting, temperature values and air humidity levels. A separate module is used to control individual parameters. The ESP8266 NodeMCU board receives a stream of digital signals, which are then processed by the processor on the module. These parameters' threshold values are set manually utilizing IoT user interfaces like the Blynk Android app on mobile phones. The use of Internet-of-things (IoT) in greenhouses and the way it can lead to smart agriculture are the subjects of research in [7]. It is possible to collect valuable information and perform early fault detection and diagnosis by using various sensors to monitor various parameters such as humidity and the concentration of water nutrients, pH and electrical conductivity (EC), temperature values, intensity of UV light, mist, CO2 levels, and insecticides or pesticides. A decision support system (DSS) is used to manage and coordinate all activities in the system. A new smart and sustainable IoT-based solution is proposed in this work, which considers the various challenges of greenhouse rose farming. The article of [8] describes how to build a wireless system to monitor and control the temperature, humidity, and soil moisture of a greenhouse. A control system for automating various microclimate parameters is designed to optimize parameters and water utilization. The advanced sensor node processes sensor data and triggers actuators using an Arduino microcontroller programmed with a predefined threshold. That data is then sent to a remote monitoring mobile application like the Blynk app. Greenhouse automation efficiently acquires and controls microclimatic parameters. It also reduces maintenance work, which is good for gardeners, farmers, and agricultural researchers.

2. The proposed smart greenhouse system

First, summarization the implementation phases of the project starting from selecting a suitable project title and going through literature review, the proposed design and assembling components, and finally connecting and testing the project circuitry and writing the project report and recommendations.

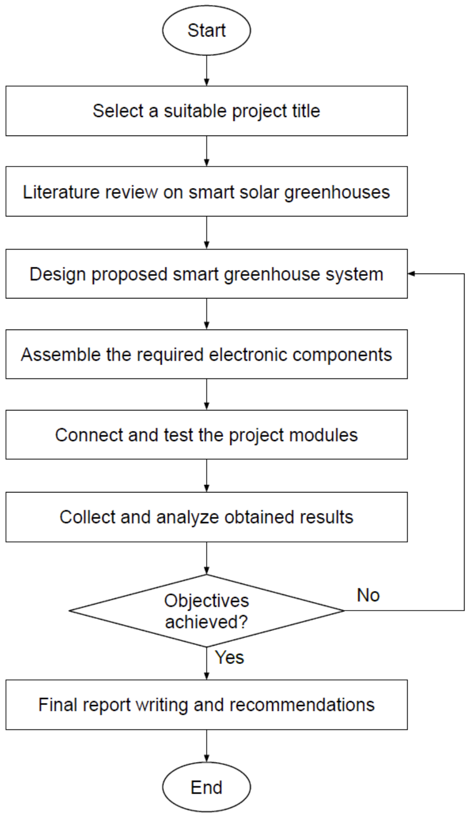

Figure 1. International Conference on Smart Grids

It is critical to maintain controlled lighting and temperature within a greenhouse environment. Plants can be damaged or killed in a matter of hours due to changes in lighting and temperature. In greenhouses, remote monitoring devices can safeguard expensive plants from excessive temperature fluctuations or poor lighting. This is the reason why we have chosen advanced components to design and build the proposed system.

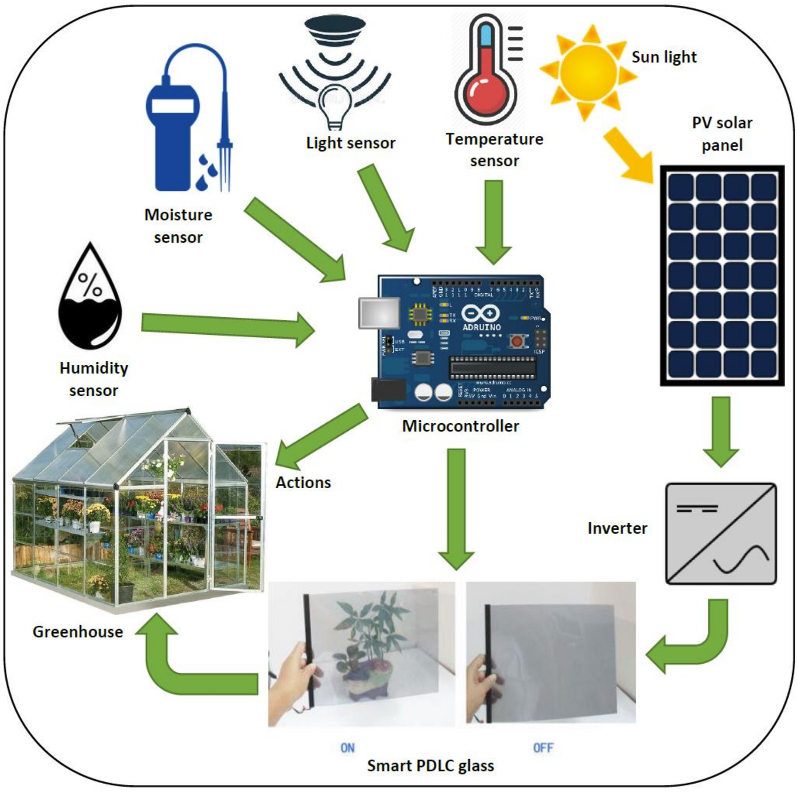

Figure 2. The proposed smart greenhouse system design

Figure 2. The proposed smart greenhouse system design shows the proposed model for mart solar greenhouse system design. In the core of our system design is the Arduino microcontroller, it connects between different components of the project and regulates different functions and phases of the real project circuitry. The second most important component is the polymer dispersed liquid crystal (PDLC) Smart Glass which is used to control lighting in the greenhouse through control of the applied voltage. The PV solar panel there's also a core component in our project as it collects light from the sun and stores it so we can power different project components.

Sensors and communication technologies in smart greenhouses allow them to monitor their environment 24 hours a day, seven days a week and automatically record and transmit data. For example, smart algorithms are employed in an IoT platform to identify potential issues and abnormalities. As a result, on-demand control of HVAC, lighting, irrigation, and spraying operations is possible. The construction of predictive models for the assessment of crop disease and infection risks is made easier by continuous data monitoring [1].

The flow chart of the system operation is depicted in Figure Error! **No text of specified style in document.**. The workflow of the system starts with reading data from different sensors and determine through some logic if the ideal conditions are met. Then, based on the data collected from sensors and after applying they specified rules the actions to be taken are decided. The greenhouse supervisor and workers are informed about the decisions made through the IOT system. If no decisions could be made, the greenhouse smart system directs the supervisor to seek information from experts.

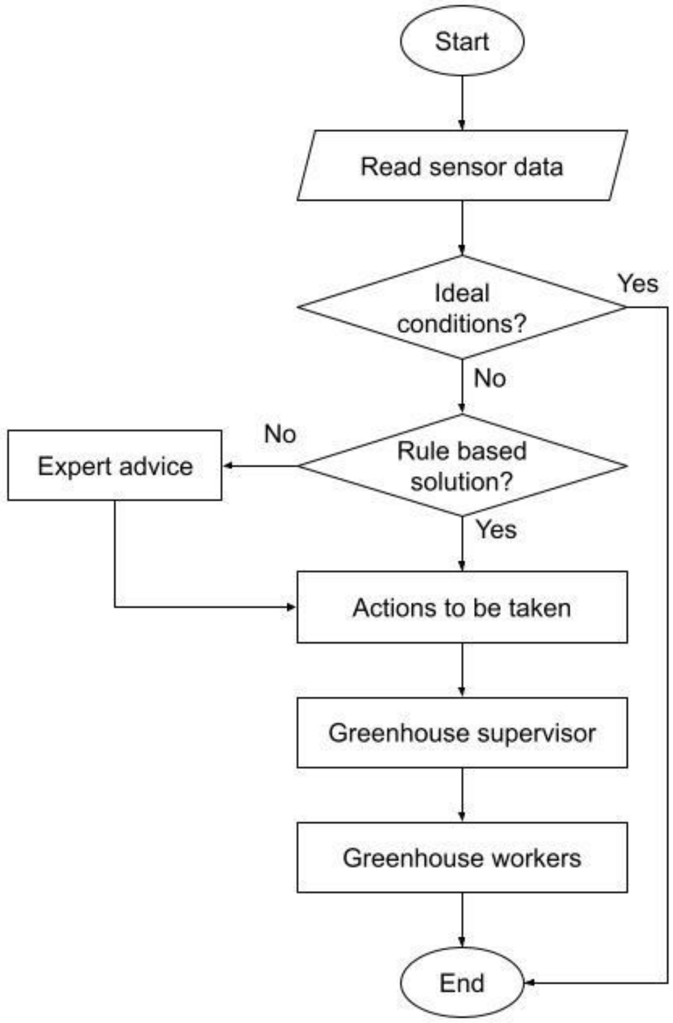

Figure **Error! No text of specified style in document.**. The system flow of the proposed system

3. Implementation and results

LDR, humidity, temperature and soil moisture sensors collect data for the current environment conditions. The collected sensor data are compared against predetermined rules. Eight possible cases have been studied. In case all rules fail, the system automatically communicates with the greenhouse owner and agriculture expert. **Error!**

Reference source not found. shows the test cases we used in this paper. The implementation of the system is shown in Fig 4.

Table 1. Appearance properties of accepted manuscripts

Temperature	**Soil moisture**	**light intensity**	**Action Taken**
low	low	low	PDLC ON, watering
low	low	high	PDLC OFF, watering
low	high	low	PDLC ON
low	high	high	PDLC OFF
high	low	low	PDLC ON, watering, fan ON
high	low	high	PDLC OFF, fan ON, watering
high	high	low	PDLC ON, fan ON
high	high	high	fan ON, PDLC OFF, contact owner

Figure 4. Implementation of the system: PDLC is on one the left and PDLC is transparent on the right

4. Conclusion

This paper presented in details the different hardware components used in the to implement the greenhouse system. The connection diagram of each component has been shown and preliminary tests. Thereafter, the experimentation results have been presented. Different cases of operations have been studied. In each case, a suitable action is taken based on predetermined rules. The decision rules are based on measurement data collected from the sensors. If all the predetermined rules fail to take a suitable action the system will automatically communicate with the greenhouse owner and agriculture expert. The proposed system has achieved its goals and it has a potential to greatly impact the greenhouse design and operation in local community.

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