DESIGNING AN AUTOMATED GREENHOUSE USING IoT TECHNOLOGIES

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Abstract. *The greenhouse is an efficient method to deal with increasing food demands caused by the unprecedented rise in worldwide population over the last century. It's a form of smart farming that allows the growth of off-season crops or plants incompatible with the local climate. The advancements in the domain of IoT (Internet of Things) allow including smart solutions to control the climate within the greenhouse and specific parameters to cater to the plants (humidity, temperature, irrigation, soil condition, etc.) most efficiently. The following article describes the design and implementation of an autonomous greenhouse.*

Keywords: *greenhouse, internet of things, sensors, automation, environment, agriculture.*

Introduction

The expansion of sustainable agriculture is promoted by the smart greenhouse technology that brings a viable solution to the challenges that have impacted developing countries. Strengthening yield, and diminishing damaging effects of climate change, the smart environment can provide a solution that ensures a prosperous future for worldwide communities.

To fulfill the expanding need for food while reducing its effect on the environment, innovative approaches have become essential considering the increasing global population and the unusual standards set for the agriculture. Smart greenhouse technology has begun to emerge as an alternative option for countries that are facing major challenges due to climate change.

This article explores the revolutionary impact of a smart greenhouse in countries that struggle, or are in development. This system helps farmers to overcome the failure of crops and other issues, smart farming is a potential path to economic growth, and reduced poverty. This is a solution that empowers local farmers to adapt to a new era of agriculture while using innovative methods which leads to improved production, through a sustainable solution with great economic potential.

Solution proposal

The Internet of Things, also known as IoT, has advanced in a huge level in the past years which allowed the integration of self-reporting devices that communicate and interact with each other and their users in real-time to achieve a goal. One of the most popular uses of IoT are smart environments. A smart environment is a collection of devices that can monitor, control and regulate information. The network-connected equipment used to monitor a smart ecosystem include actuators, microcontrollers, and sensors. To improve services for people, the physical smart environment has an intelligent design and gains from the interface of numerous gadgets and computer systems [1]. To reduce the problems created by the increasing population rate and drastic climate changes it is proposed a smart greenhouse system.

IoT technologies are integrated into smart greenhouse systems to increase the performance in agricultural yields. Sensors and digital components are used to monitor and control environmental factors, the most important feature of these intelligent structures is that it does not require human involvement.

Requirements Specification

User stories and system requirements should be outlined to develop an IoT-embedded greenhouse management system. Functional requirements define the specific functions of the system or a component of it, representing the summary of the input and output state of the system. They are product features or functions that developers must implement to enable users to accomplish their tasks [2]. For different types of users, there are several needs such as:

A greenhouse manager needs remotely monitor temperature and humidity levels in the greenhouse, to receive real-time alerts on mobile devices in case the temperature exceeds a certain threshold. It is needed because it needs to ensure the optimal conditions for growing the plants without being physically present. In the case of a notification system, it is needed to take immediate action to prevent heat stress or any other damage to the plants.

A greenhouse owner is required to implement an automated irrigation system based on the soil moisture levels and the specific conditions of the plants. This ensures consistent watering of the plants, prevents over and under-watering, and reduces the water resource costs optimizing for reducing resource wasting.

A greenhouse maintenance technician demands remote diagnosis and troubleshooting equipment problems using sensor data to reduce interruptions and ensure smooth operations of the greenhouse system.

A crop specialist desires to analyze the health of the agricultural crops by identifying the parameters that do not fit into the norms including leaf color, growth rate, and presence of pests or diseases. It is an essential aspect to intervene quickly and efficiently in case of issues to avoid production losses.

As for the nonfunctional requirements which are system qualities that guide the design of the solution and often serve as constraints across the relevant backlogs [3]. Some of the nonfunctional requirements of the greenhouse systems include:

- Environmental impact which enhances energy and sustainable resource usage by optimizing and reducing water and energy wasting minimizes the impact on the environment at a global level if introduced on a larger scale.
- Revolutionary performance of production, making the system able to perform multiple tasks in a specific time interval to process and analyze data collected from the sensors.
- Availability, for the greenhouse a high availability rate means a minimal suspension time in case of component inactivity.
- Usability enhances the easily manageable monitoring system for different user personas such as farmers, technicians, or researchers. Includes a user-friendly interface for easy access to for quick navigation through past statistics and trends, as well as for monitoring and managing the conditions in the greenhouse.

Architectural Design

The system architecture represents a theoretic model that defines the structure of the system, its behavior and how the components interact with each other [4].

To provide comprehensive system monitoring, multiple sensors were placed throughout the greenhouse. The greenhouse system includes the necessary components such as: irrigation, shading, ventilation, humidifier, temperature, humidity sensors, light sensors, soil moisture sensors, CO_2 sensors, and soil pH sensors.

The architectural design of the greenhouse system revolves around several principles. First, is scalability, that is the greenhouse can have any dimensions. This space is going to be filled with "zones", which are spaces where the plants are planted and grown. Each zone within the greenhouse will be configured with the necessary sensors and actuators, which will ensure that the plants in the zones are in the proper conditions.

The second principle that this system follows is that you can grow any type of plant in the greenhouse. The client will use the application to choose the plant to grow in a specific zone and the perfect conditions for the growth of this plant is going to be set automatically by our system.

Furthermore, the third followed principle is the ability to monitor and analyze the zones. This suggests an application that will allow the client in addition to initializing the zones with plants to also monitor their growth and check sensors and actuators' data.

The below block diagram (Figure 1) represents the main structure of our system. It contains three entities that communicate with each other.

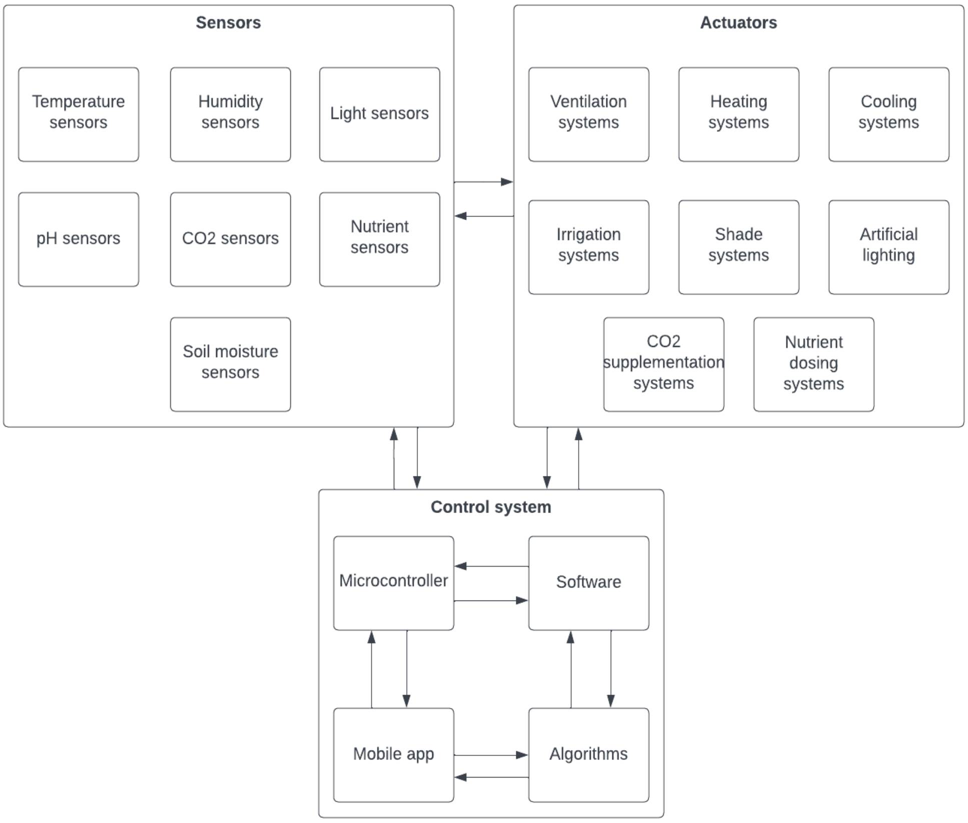

Figure 1. Block diagram of the greenhouse system

Conclusion

All in all, embedded systems and the Internet of Things bring a new era in agriculture. This greenhouse project will significantly help farmers, as well as enthusiasts in the field to grow agricultural products with the highest efficiency and yield. The mentioned system/software will ensure an individual growth plan for each plant, an automatic monitoring system, and a friendly user interface which will make it convenient for the farmers to use it.

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