IoT-Based Mushroom Cultivation System with Real-Time Environmental Monitoring and Control Using ESP8266 and Blynk Platform

Cherry Mae Bunag
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
@gmail.com

Ivy Buscar
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
@gmail.com

Geuel Darvie Cuevo
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
geueldarviecuevo@gmail.com

Jeffrey Equipaje
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
@gmail.com

Zyrine Lagman
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
@gmail.com

Jomer Catipon
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
jomer_catipon@tup.edu.ph

Jessica Velasco
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
jessica_velasco@tup.edu.ph

John Peter Ramos
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
johnpeter_ramos@tup.edu.ph

Elmar Francisco
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
elmar_francisco@tup.edu.ph

Mark Melegrito
Department of Electronics Engineering
Technological University of the Philippines
Manila, Philippines
mark_melegrito@tup.edu.ph

Abstract — This study integrates ESP8266 microcontrollers for wireless connectivity and energy efficiency, using sensors to collect real-time temperature, humidity, CO2 levels, and substrate moisture data. Transmitted via the Blynk server, this data dynamically adjusts environmental conditions within a solar-powered enclosure. The system optimizes the cultivation of Oyster, Button, and Yanagi mushrooms, using the ANFIS model to identify optimal conditions for each variety. The results show the system's response time in displaying real-time sensor outputs and executing remote control commands was found to be nearly instantaneous, with minimal latency, making Blynk suitable for applications requiring immediate interaction and control.

Keywords— *Adaptive Neuro-Fuzzy Inference System (ANFIS), Urban Agriculture, Internet of Things (IoT), Fuzzy Logic, Blynk*

I. INTRODUCTION

Mushroom cultivation presents a labor-intensive task demanding continuous monitoring of environmental parameters for successful growth. Unlike many crops, mushrooms require specific environmental factors, including temperature, humidity, substrate moisture, and CO2 level, to thrive. Typically, mushrooms cultivated using manual methods need cultivators to invest significant time as sustaining the parameters is difficult to carry out constantly. Consequently, cultivation becomes challenging, potentially leading to pests and diseases that can cause complete damage to the mushroom bags. With the continuous development of the Internet of Things (IoT), automated monitoring and control capabilities become more accessible, saving time and labor for growers [1].

By integrating automated systems, such as IoT technology and sensor networks, this research aims to revolutionize mushroom cultivation practices. The study focuses on developing a system that utilizes sensors for monitoring crucial environmental parameters like temperature, humidity, and CO2 levels. The data collected is processed by microcontrollers, enabling real-time adjustments and optimizing growing conditions for mushrooms. The implementation of the Blynk platform enables remote monitoring and control, offering growers flexibility and efficiency in managing cultivation environments. Through this, the researchers aim to enhance the sustainability and productivity of mushroom cultivation while reducing labor requirements and production risks.

Globally, mushroom cultivation has been sought out due to the demand for fungi with nutritional and medicinal applications [2]. Mushrooms are high in protein, carbohydrates, and dietary fiber, and contain essential minerals such as potassium, and vitamins like niacin, riboflavin, and folates [2]. Additionally, mushrooms contain bioactive secondary metabolites with antioxidant, antiviral, and anti-tumor effects. However, mushroom farmers struggle with conventional production methods, as mushrooms rely on environmental parameters that are very hard to control manually. Challenges arise from the lack of real-time monitoring and control of these parameters. The rise of technological advancements, particularly IoT, offers a sustainable solution by enabling precise control and real-time adjustments, enhancing traditional production methods.

II. Related Works

In the article [3], the total yield of mushrooms is directly impacted by poor conditions which are caused by the labor-intensive conventional way of monitoring and controlling environmental factors such as temperature, humidity, and carbon dioxide concentrations. Because of this, integration of the Internet of Things (IoT) can offer a solution as it can permit real-time monitoring and maintenance of crucial environmental parameters.

Now, the same article [3] presented a smart environmental monitoring system using IoT for the cultivation of mushrooms. In the author's system, ESP8266 was used as the microcontroller as it has a built-in Wi-Fi module that collects real-time data from environmental sensors such as the DHT-11, and MQ135. All the gathered data is sent to the internet using the ThingSpeak platform to enable monitoring and analysis. Additionally, the problem with the conventional way of mushroom cultivation impacts lower yield as the environmental parameters were not maintained to the ideal conditions preferred by the mushrooms. So, the system they designed aims to provide automatic control of the conditions through the involvement of an irrigation system controlled by the microcontroller using the analyzed data as its basis for turning the system on and off.

On the other hand, in the article of [4], they utilized an ESP8266 microcontroller to design a smart agriculture system but using the Blynk application platform. The difference between these platforms is that the ThingSpeak platform used in the previous system only collects, visualizes, and evaluates data in real-time, while the Blynk platform can do analytics same with ThingSpeak, and it contains more features such as a customizable dashboard, interactive buttons for remote control, as well as push notifications.

III. Methodology

A. System Flow

As shown in Figure 1, the control and monitoring stage involves establishing connections with the Blynk IoT Cloud enabling real-time monitoring and control. The Blynk app grants a user-friendly interface to visualize and monitor environmental parameters, allowing users to monitor real-time values and receive alerts for optimal mushroom cultivation conditions. In the output stage, real-time temperature, humidity, CO2 level, and soil moisture values are displayed on the Blynk Dashboard, and an LCD screen connected to the NODE MCU ESP8266 provides visual feedback and relevant information.

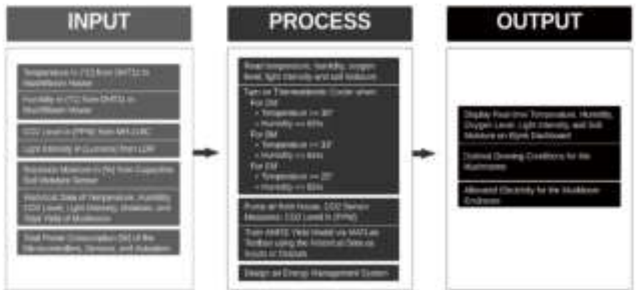

Fig.1.Input - Process – Output (IPO)

B. Designing an Application to Control the IoT for Mushroom Cultivation Enclosure

Figure 2 illustrates the real-time monitoring system of MushBloom using the Blynk IoT. In the first dashboard, the three widgets namely oyster, button, and yanagi display. Thereafter, the following dashboards showcase the real-time monitoring parameters to monitor. The data acquired by the sensors is shown in real-time together with its temporal variations through a graph feature in each. Moreover, it also consists of a real-time controlling system where the parameters can be adjusted for the needed optimal mushroom growth.

Additionally, figure 3 illustrates some of the functions of the Blynk dashboard, such as clicking the bell button that will ping the user to the notifications and alerts. In contrast, the plus button will enable users to add a device through different methods. On the other hand, the bell button inside each widget, namely Oyster, Button, and Yangi, will inform the user of the specific date and time the device went online and offline.

Fig.2. iMushBloom (Blynk Application)

Fig.3. iMushBloom Notification System (Blynk Application)

IV. RESULTS AND DISCUSSION

A. ANFIS Model for Environmental Control Systems

The following provides a comprehensive overview of various environmental control systems trained using the Adaptive Neuro-Fuzzy Inference System (ANFIS). The figures and descriptions illustrate the design, training, and performance of models for predicting temperature, soil moisture, CO2, and humidity. Each model is tailored to optimize specific environmental conditions by leveraging fuzzy logic rules and neuro-fuzzy training techniques. Below are the trained ANFIS models and their respective figures, showcasing each system's intricate design and error analysis.

Figure 4 shows the Neuro-Fuzzy Designer interface for training an ANFIS temperature prediction model. The x-axis represents the dataset index, and the y-axis represents the output. The model activates the thermoelectric cooler (output value 1) when the temperature Two inputs are used: the exact temperature and a binary indicator (0 or 1) for the thermoelectric cooler state. The interface includes options for data loading, FIS generation, training optimization, and testing.

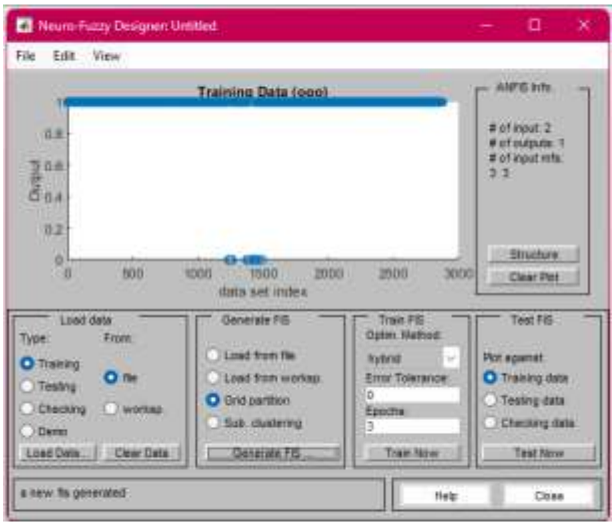

Fig.4.Designing a Fuzzy Logic System for a Temperature Prediction Model

Figure 5 depicts the ANFIS Model Structure for the temperature prediction system. The structure comprises various layers, including inputs, input membership functions (inputmf), rules, output membership functions (outputmf), and outputs. The model uses two inputs: the exact temperature and a binary indicator for the thermoelectric cooler state. The logical operations (and, or, not) are visualized with blue and red nodes, facilitating the interpretation and processing of fuzzy rules.

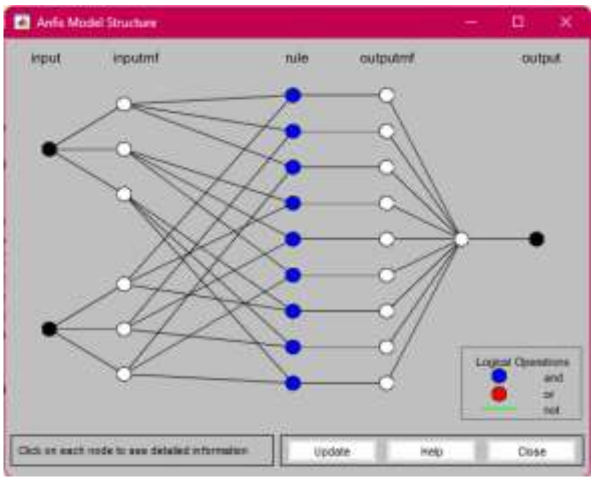

Fig.5.ANFIS Model Structure for Temperature Prediction

Figure 6 displays the Rule Editor interface for the temperature model. The fuzzy rules define thermoelectric cooler (TEC) behavior based on COLD, NORMAL, and HOT temperature categories. The rules specify conditions such as OFF if the temperature is between 22 and 30 degrees Celsius and the category is COLD. This comprehensive set of rules enables the precise control of the thermoelectric cooler based on the current temperature conditions.

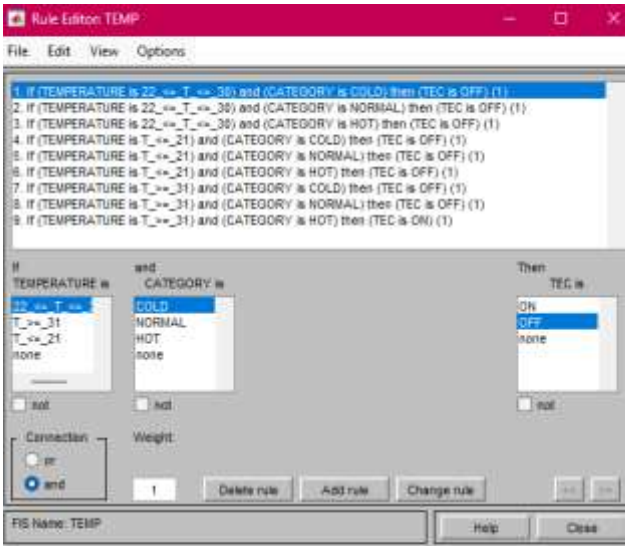

Fig.6. Fuzzy Rules for Temperature Model

B. *iMushBloom (Blynk Dashboard)*

The Blynk platform demonstrates real-time sensor outputs and executes remote control commands with a response time that reflects the actual environmental parameters during observation. The provided screenshot, Figure 7, showcases the Blynk dashboard featuring a timestamp displaying the current date and time. This timestamp corresponds to the real-time parameters shown in the Blynk widget and graph, such as 5/22/2024 at 16:28 and 5/22/2024 at 16:33. The dataset includes entries detailing the environmental metrics recorded at one-second intervals. Notably, the data entries at 16:28 and 16:33 demonstrate identical parameters, further affirming the consistent real-time updates provided by the Blynk platform. Therefore, the response time of the Blynk platform in presenting real-time sensor outputs and executing remote control commands aligns closely with the actual environmental conditions being monitored.

Fig.7. Blynk Real-Time Dashboard

The Blynk platform typically provides instantaneous updates reflecting real-time sensor outputs and executing remote control commands. However, occasional delays may occur, often attributed to internet connectivity issues. Researchers commonly position the internet router close to the monitoring devices to mitigate such delays. These delays are usually minimal, ranging from 5 to 10 seconds, ensuring that the data primarily reflects the current environmental conditions.

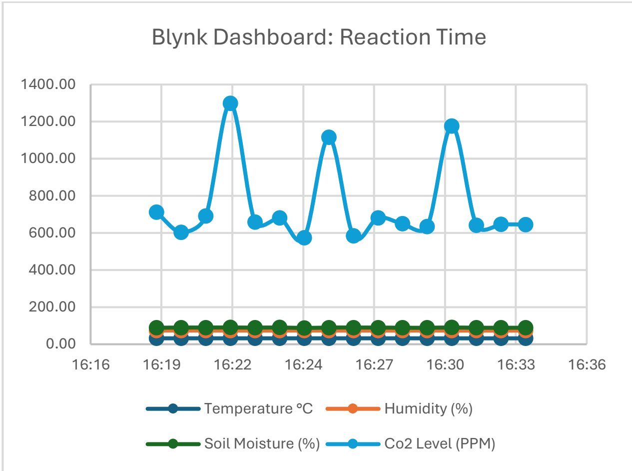

Fig.8. Blynk Dashboard: Reaction Time

V. CONCLUSION

The development and implementation of the Mushbloom system, utilizing Blynk IoT Cloud has demonstrated significant improvements in real-time environmental monitoring, and controlling in mushroom production as it can give precise temperature, humidity, soil moisture, and CO2 level readings through the integration of IoT technology, specifically the ESP8266, and the environmental sensors. With the real-time capabilities of the system, it enabled rapid transmission of updates of data, as well as timely adjustments of the environmental parameters, therefore optimizing the growth conditions, and enhancing the yield, and quality of the mushrooms. Additionally, the integration of the Adaptive Neuro-Fuzzy Inference System (ANFIS) enhanced the control of the parameters through its fuzzy logic rules, and neuro-fuzzy training techniques, which enabled precise, and intelligent control of the parameters according to the real-time data, which enhanced the ability of the system to maintain the optimal growing conditions. Overall, the Mushbloom system provided a significant improvement in the automation, and efficiency of mushroom cultivation, demonstrating the potential of IoT, and ANFIS technologies in smart farming.

REFERENCES

[1] MES, Modular Employable Skills. (2014). *Mushroom Cultivation.* [Online]. Retrieved from https://www.nqr.gov.in/sites/default/files/Curriculum_MUSHROOM%20CULTIVATION.pdf

[2] Cheung, P.C.K. (2010). *The Nutritional and Health Benefits of Mushrooms.* [Online]. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-3010.2010.01859.x

[3] *Based Smart Environmental Monitoring for Mushroom Cultivation.* [Online]. Retrieved from https://www.researchgate.net/profile/Saiful-Azimi/publication/325010990_Internet_of_Things_based_Smart_Environmental_Monitoring_for_Mushroom_Cultivation/links/5af14b490f7e9ba366454ffb/Internet-of-Things-based-Smart-Environmental-Monitoring-for-Mushroom-Cultivation.pdf

[4] Kharat, K., et. al. (2021). *A Prototype of Smart Agriculture System using Internet of Thing based on Blynk Application Platform.* [Online]. Retrieved from https://jeeemi.org/index.php/jeeemi/article/view/179/81