IoT Based Smart Mushroom Growing Kit

Ammar A.M. Al-Talib
Department of Mechanical and Mechatronics, Faculty of Engineering, Technology and Built Environment, UCSI University, 56000 Kuala Lumpur, Malaysia

Cynthia Kuan Jing Ting
Department of Mechanical and Mechatronics, Faculty of Engineering, Technology and Built Environment, UCSI University, 56000 Kuala Lumpur, Malaysia

Noor Idayu Mohd Tahir
Department of Mechanical and Mechatronics, Faculty of Engineering, Technology and Built Environment, UCSI University, 56000 Kuala Lumpur, Malaysia

Ain Atiqa Binti Mustafa
Department of Mechanical and Mechatronics, Faculty of Engineering, Technology and Built Environment, UCSI University, 56000 Kuala Lumpur, Malaysia

Tan Yong Hui
Department of Mechanical and Mechatronics, Faculty of Engineering, Technology and Built Environment, UCSI University, 56000 Kuala Lumpur, Malaysia
E-mail: ammart@ucsiuniversity.edu.my, 1001956246@ucsiuniversity.edu.my, NoorIdayu@ucsiuniversity.edu.my, AinAtiqa@ucsiuniversity.edu.my, tanyh@ucsiuniversity.edu.my

Abstract

This project introduces an IoT-based smart mushroom growing kit to meet the rising global demand for high-quality mushrooms. Various species of mushrooms can be efficiently grown in different environmental conditions with the help of IoT devices that enable farmers to regulate the climate condition according to the specific needs of each type of mushroom. The kit employs sensors and actuators, including temperature, humidity, MQ-135, and ultrasonic sensors, along with an ESP32 camera, controlled by a microcontroller. The collected data is transmitted to an IoT platform via Wi-Fi, facilitating real-time monitoring and control through a user-friendly dashboard on Blynk website and Blynk app. This innovative system optimizes mushroom cultivation by adjusting environmental conditions, offering efficiency and profitability. Users can remotely monitor and regulate the growth environment through their smartphones, enhancing the overall mushroom cultivation experience.

Keywords: Internet of Things; Environmental Condition Control, Mushroom Growing Kit

1. Introduction

With the growth of cities and urbanization in Malaysia, there is a growing demand for sustainable food production within the urban areas. Mushrooms are types of fungi that are known as high protein food which is beneficial for health. Mushrooms were mostly used in health supplements and used as an ingredient in meals to provide nutritional properties to the human body [1]. The demand for mushrooms in Malaysia was expected to increase due to the health awareness among the people increases [2]. Based on Hedley [3], the duration of the complete mushroom life cycle can vary from as short as one day to couple of years based on the types of the mushroom species. Thus, it is best to consume the mushroom fresh within a day. Other than that, drying, freezing, canning, pickling are the common processing and preservation methods to keep the mushrooms fresh [4]. Despite the fact that, Malaysia is a tropical country with suitable climates condition to grow and produce various mushrooms locally, Malaysia had imported more than five tons of mushrooms every year since 2009 and has reached up to 10 million tons in 2012 which cost more than USD 3.0 million from China [2]. This shows that, the mushroom industry in Malaysia is inadequate as the local mushroom production can barely supply enough mushroom for local consumers [5]. There are several techniques that can be used in mushroom cultivation. Machine learning technique is one of the advanced technologies used in large-scale farming for crops monitoring and pest control. Fuzzy logic technique and command control programming were also used in urban farming and greenhouse to monitor the environmental parameters [6]. However, the cost of implementing advanced technology can be relatively high, making it difficult for small-scale farmers to afford [7].

The paper shows the development of an IoT-based smart mushroom growing kits that allows beginners and urban farmers to monitor and remotely control the growing condition of mushroom easily through smart device without being worried or being at the presence using Blynk IoT application and sensors. The automated IoT smart mushroom growing system can help users to take care of the mushrooms and save user time while enjoying growing mushrooms at home for cooking or to earn extra income.

2. Methodology and Experimental Setup

ESP32 microcontroller was used in this project. The IoT platform chosen for this project is Blynk as it is a mobile application-based platform, easy to use and it offers a user-friendly interface to control and monitor the IoT devices. The controlling parameters and output devices of this project consist of temperature, relative humidity, carbon dioxide level, water level, LED light, fan, misting system and camera.

A. System block diagram

The IoT-based smart mushroom growing kit was designed to monitor the growth of mushrooms under the desirable environmental condition by obtaining data from the sensors and controlling the actuators using IoT technology. Fig. 1 shows the block diagram of the IoT system where the input and output devices were connected to the microcontroller and the ESP32 microcontroller communicates with Blynk IoT platform through Wi-Fi internet connection.

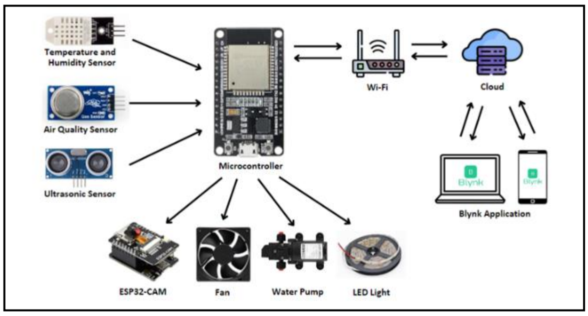

Fig. 1 Block diagram of the system

B. Control System wiring diagram

The control system consists of three subsystems which are the lighting, ventilation and misting system. Fig. 2 shows the wiring connection of the system which consists of the microcontroller, sensors, actuators and power supply. A three-pin plug was used to connect the 240V AC input power generated from the power station to the house to the power supply transformer to convert voltage 240V AC to 12V DC. Then, the 12V DC output voltage positive and negative pole were connected to the terminal block to supply 12V DC to the fan, water pump, LED light and buck converter. In addition, the ESP32 microcontroller, MQ-135 air quality sensor, HC-SR04 ultrasonic sensor, ESP32-CAM and relay were connected to the output of the buck converter where 12V DC is step down to 5V DC. Lastly, the DHT22 temperature and humidity sensor was powered with 3.3V DC from the ESP32 microcontroller.

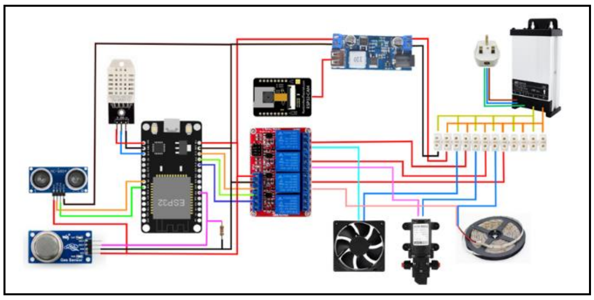

Fig. 2 System wiring diagram

C. System structure design

Fig. 3 shows the structure design of the mushroom growing kit using SolidWorks software which consists of the misting system, LED light, ESP32-CAM for video streaming, MQ-135 air quality sensor, DHT22 temperature and humidity sensor, a DC fan and an ultrasonic sensor. The material used for the mushroom growing kit structure is stainless steel with a dimension of 450mm length, 360mm width and 690mm height. The kit was designed to fit 10 mushroom bags in pyramid arrangement. The electrical component section was designed to keep the electrical components safe on top of the kit and the water tank section was used to place the plastic container used as the water tank for the misting system, while the mushroom room section was used to place the mushroom bags for mushroom development. The components used in the IoT-based smart mushroom growing kit were arranged and labeled in Fig. 3 and Fig. 4.

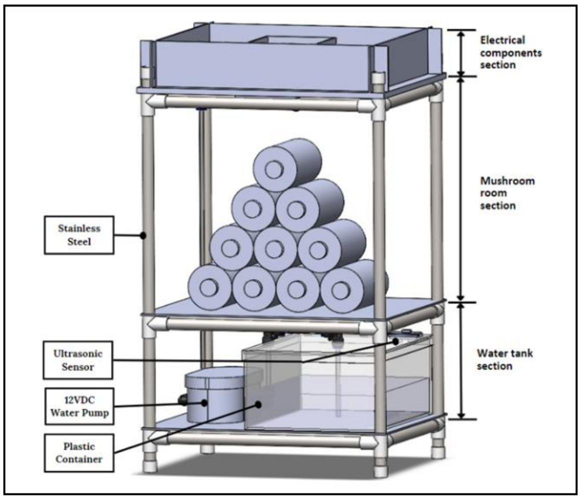

Fig. 3 IoT-based smart mushroom growing kit section

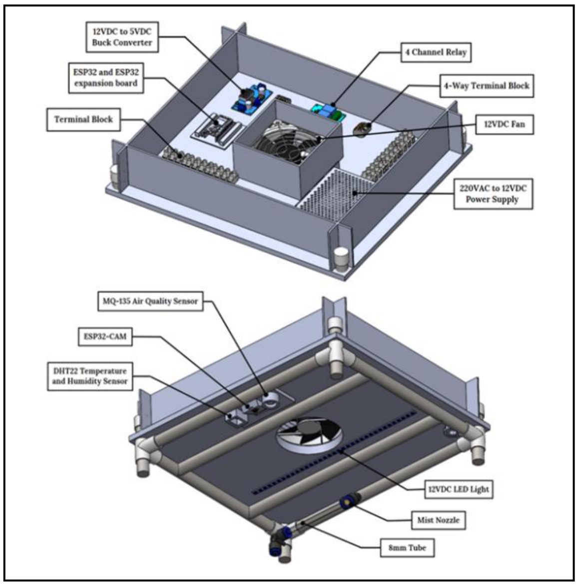

Fig. 4 IoT-based smart mushroom growing kit components labels

3. Results and discussion

A. IoT-based smart mushroom growing kit prototype

Fig. 5 shows the kit prototype when the LED light button is pressed as shown in Fig. 6. on Blynk IoT application. Blue light spectrum was used in the prototype due to blue-colored LED light is the most effective color in enhancing the development and production of the oyster mushroom [8].

Fig. 5 Mushroom growing kit prototype

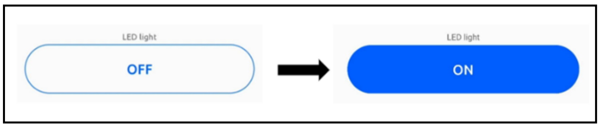

Fig. 6 LED Light setting on Blynk app interface

Desired value for temperature, relative humidity and CO_2 concentration can be set by user in the Blynk app as shown in Fig. 7. Once the desired values are set, the data will be read by ESP32 microcontroller, and the actuators will operate according to the command given by the ESP32 microcontroller to alter the kit environmental temperature, relative humidity and CO_2 concentration. The user is able to monitor and control the kit from the Blynk IoT application as measured readings from the DHT22, MQ-135 and ultrasonic sensors are displayed on the Blynk app IoT interface as shown in Fig. 8 and user could view the live-stream video by clicking on the video stream button on the Blynk app as shown in Fig. 9.

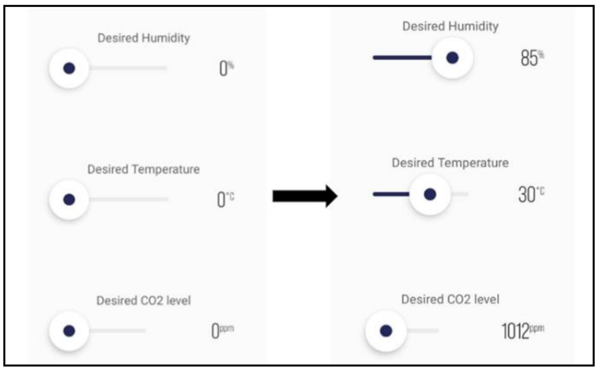

Fig. 7 Desired controlling variables setting on Blynk app interface

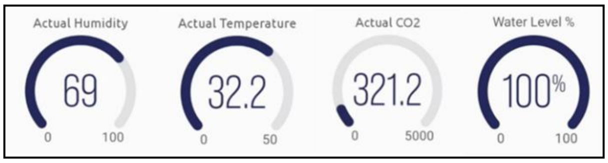

Fig. 8 Measured readings from sensors displayed on Blynk app interface

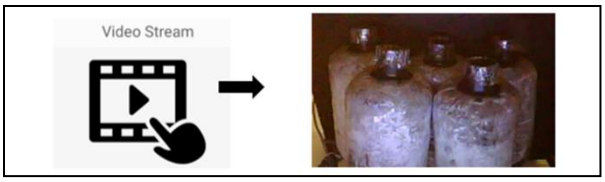

Fig. 9 Video stream button

B. Sensor detection accuracy results

To analyze the accuracy of the sensors, the temperature, relative humidity, CO_2 concentration level and water level readings obtained from a commercial air detector, and a ruler were compared with the ultrasonic sensors used in the kit. After eight attempts of testing, the result shown that temperature and humidity sensor (DHT22), air quality sensor (MQ-135) and ultrasonic sensors (HC-SR04) have high accuracy in detecting temperature, relative humidity, CO_2 concentration level and water level as it has low percentage error below 6%.

C. Results before and after IoT system implementation

Desired temperature value was set at 27℃. Based on Fig. 10, temperature value detected outside the prototype kit remain constant at 28℃ and the temperature value measured from the DHT22 sensor inside the prototype kit reduced from 28.1℃ to 27.8℃ throughout the 10 minutes testing. This has proven that the prototype kit was able to work according to the microcontroller command by reading the desired value from the Blynk IoT application to turn on the fan. However, the prototype kit was only able to reduce the temperature up to 0.3℃ due to there is no cooler and heater implemented in the mushroom growing kit.

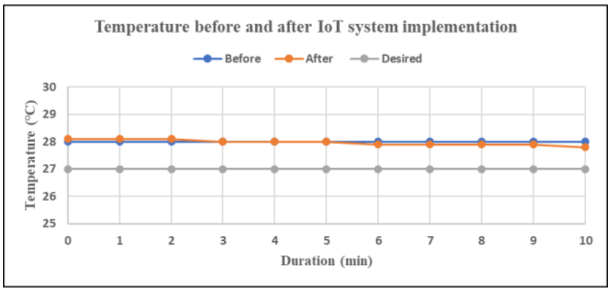

Fig. 10 Temperature before and after IoT system implementation graph

Moreover, the desired value for relative humidity was set at 70%. The relative humidity value detected outside the prototype kit has a slight change from 61% to 63% as shown in Fig. 11. However, it does not reach the desired humidity value. The relative humidity value measured from the DHT22 sensor inside the prototype kit increases from 60.4℃ to 69.5℃ throughout the 10 minutes testing. This has proven that the misting system in the prototype kit was able to work effectively by proving sufficient humidity required for the mushroom development when the humidity detected is low.

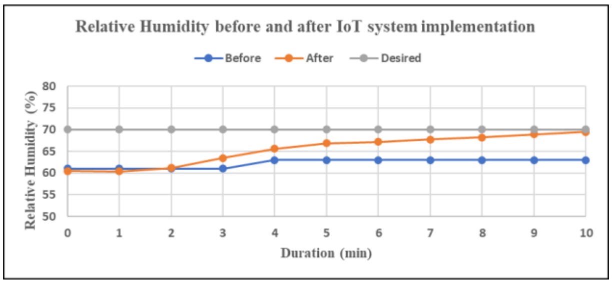

Fig. 11 Relative humidity before and after IoT system implementation graph

D. Mushroom harvest result

A mushroom harvest cycle was conducted to observe the performance of the IoT-based smart mushroom growing prototype kit and the traditional mushroom cultivation methods. Fig. 12 shows the mushroom harvest using traditional method and Fig. 13 shows the mushroom harvest using the IoT-based smart mushroom growing prototype kit.

Fig. 12 Mushroom harvest using traditional method


Fig. 13 Mushroom harvest using prototype kit

The traditional harvest method took eight days for the primordia formation while the mushroom harvest using prototype kit only took five days which is three days faster than the traditional harvest method. Hence, the duration for the mushroom fruitbody development using traditional method is longer compared to the mushroom fruitbody development using prototype kit. Other than that, the weight of the mushroom produced using the traditional method was only 49 grams which is 11 grams lesser than the 60 grams weight of the mushroom produced using the prototype kit. The mushroom produced from the prototype kit is bigger in size and the color is more even compared to the mushroom grown with the traditional method. This shows that the mushroom harvest using prototype kit is more efficient compared to the traditional method. By using the traditional method, user must continuously damp the cloth in water and place the cloth on top of the mushroom bag once the cloth is dry. The prototype kit could automatically control the environment condition to ensure the surrounding has enough moisture which could help in speeding up the mushroom development process and to produce good quality mushrooms.

4. Conclusion

The proposed IoT-based smart mushroom growing prototype kit has achieved all requirements to control the environmental condition for the mushroom's development. The kit was capable of controlling the environmental variables based on the desired value set by the user. An IoT system was created with Blynk application to control and monitor the growth of mushrooms through the smartphone. Other than that, users could obtain the data stored on the google sheet for data analysis. The kit was considered a successful innovation to support the sustainable development goals (SDGs) to reduce the use of resources and waste in the mushroom growing process and increases the efficiency and productivity of the mushroom growing operation.

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Authors Introduction

Ammar Abdulaziz Al Talib

Dr. Ammar Al Talib has finished his B.Sc and M.Sc degrees in Mechanical Engineering from the University of Mosul/Iraq. He has finished his Ph.D degree from UPM University / Malaysia. He is also a Chartered Engineer and Member of the Institute of Mechanical Engineers / UK. (CEng. MIMechE). He has developed all the Postgraduate Programs at the Faculty of Engineering at UCSI University / Malaysia and worked as the Head of Postgraduate and Research department at the same faculty for the years 2010-2018.

Ms. Cynthia Kuan Jing Ting

She received her Bachelor's degree in Mechatronic Engineering in 2023 at UCSI University, Kuala Lumpur. Her field of research is Internet of Thing (IoT) technology.

Ir. Noor Idayu Binti Mohd Tahir

She graduated from University Teknologi MARA, Malaysia in Mechanical Engineering. She was design engineer in oil and gas industries for 7 years. Currently, she works as a lecturer under the Department of Mechanical and Mechatronics, Faculty of Technology and Built Environment, UCSI Kuala Lumpur. Her research interests include design and autonomous robotics.

Ms. Ain Atiqa Binti Mustafa

She received her Master's degree from the Faculty of Electronic & Computer Engineering, Universiti Teknikal Malaysia Melaka, Malaysia in 2017. She is currently a Tutor under department of Mechanical and Mechatronics Engineering, UCSI University, Kuala Lumpur.

Dr. Tan Yong Hui

Dr. Tan Yong Hui finished her B.Sc and M.Sc degrees in Biotechnology from UTAR in 2011. She has finished her Ph.D in mushroom biotechnology from University of Malaya in 2022. She is currently a Lecturer under department of Biotechnology.