High Tech Housing for Sustainable Mushroom Cultivation

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Abstract **Mushroom cultivation is important due to its nutritional value, medicinal value, income generation and employment creation. Currently the mushroom cultivation are just being done in a very primitive way. Thus it is crucial to upgrade the facilities to increase yield through optimum resources. . The system developed is a High Tech system for mushroom cultivation to address the automation in the production of different types of mushroom for all seasons. This system comprises an environment monitoring and controlling system to monitor and control the environment conditions in mushroom farm. It includes monitoring of temperature, humidity, carbon dioxide concentration and light intensity using different sensors in a mushroom house on an android device by using an online platform called adafruit.io. The controlling is based on feedback from the sensors thereby providing ambient climatic conditions for mushroom growth. This enables the year round production of any type of mushrooms.**

Keywords —Atmega, Internet of Things, Master and Slave System, Monitoring and Control, Wi-Fi Module

I. Introduction

Mushroom industry is growing day by day due to mushroom's benefits. Different type of mushrooms requires different climatic conditions for their growth. It is difficult to maintain the temperature, humidity, carbon dioxide and light intensity levels for the entire year. Hence, to enable year round production of different types of mushroom, there is the requirement of a smart cultivation system that enhances mushroom cultivation thereby providing profit to farmers. The system involves sensors for sensing the atmospheric conditions within the mushroom farm and a controlling part that works based on the outputs from the sensors thereby maintaining the required conditions for the growth of the type of mushroom chosen by the farmer.

All the existing techniques are used for the production of mushroom spawns and maintaining some conditions for particular type of mushroom cultivation. Different climatic condition sensors play an important role in modern agriculture. The use of sensors in various agriculture minimizes the environmental impact on crops, helps in increasing yield and saving cost of operation. In Malaysia, among different crop industries, the mushroom industry is a comparatively new and small scale. As most of the mushroom farms in Malaysia are small-scaled, their production capability is limited by inadequate environmental control system and the lack of financial resources to upgrade the systems. This paper presents an environmental monitoring and controlling system to monitor and control the environmental conditions in a mushroom farm [1]. It enables user to monitor temperature, humidity, carbon dioxide concentration and light intensity in a mushroom farm on an android device by using Thing-Speak online platform. The control algorithm is able to control devices in a mushroom farm automatically based on feedback from the sensors to maintain the environment in an optimum condition for mushroom growth.

The need of food and limitation of space or land as an agro-economic activity make urban farming technology is becoming popular and has become one of promising solution for securing food supply. Apart from that, extreme weather changes and climates affect the production of crop, thus increasing their prices and lowering the quality of the crops produced. Hence, this paper present an internet of things (IoT) based monitoring and environment control for indoor cultivation oyster mushroom, which is a smart urban farming system that requires less maintenance, less manpower and saves a lot of space[2]. Furthermore, this project is dedicated to improve and enhance the conventional plantation system in general. Using IoT platform will enhance the capability of current equipment

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for remote monitoring purpose and at the same time log the data for analysis and references.

To maintain and control the growth process and monitor mushroom growth in real time online, the design scheme of the environment monitoring system based on Internet of things was put forward on the main climatic conditions that influence the growth of mushroom. And according to the mushroom climatic conditions, the appropriate sensor and sensor placement were chose according to the house. By using RS-485 bus technology the information acquisition module, display module, communication interface and control interface monitoring terminal were built up. For the wiring is not conducive to the place in the mushroom room, its environmental information preclude the use of wireless sensor networks. On the server side is a web house environmental monitoring system was build based on the MySQL database - On the network communication interface the ENC28J60 Ethernet controller was used[3]. In order to obtain the sensed values more accurately and effectively, loss-based retransmission detection based on the ACK scheme is adopted in the wireless sensor network. Experimental results show that this method can effectively improve the reliability of the data and maintain them.

From the literature survey, we define the objectives as to create controlled environment (Humidity control, temperature control, light control, CO_2 level control) for cultivation of mushroom year round. We use a water saving path for water saving. Vitamin enrichment of mushroom quality by exposing to UV light. Here we provide an IoT based data acquisition through mobile phone using adafruit technology.

II. EXPERIMENTAL SETUP

2.1 METHODOLOGY

Develop a mushroom housing for six beds where Humidity measurement and control, Temperature measurement and control, Light intensity measurement and control, UV exposure for higher vitamin D content, data acquisition of the above through mobile phone are implemented.

Figure 1 shows the methodology of the work. Firstly, the system functionality is designed. Then, the interface circuits are designed and built one by one. The first interface circuit designed is the interface circuit of temperature and humidity sensor, followed by the interface circuit of light dependent resistor and interface circuit of CO2 (carbon dioxide) sensor. Next, the source code is drafted. Then, the circuits are combined and tested to see if it fulfills the requirement. The trouble shooting process is repeated until the system works well and fulfills its requirements. Lastly, testing is done and results are evaluated.

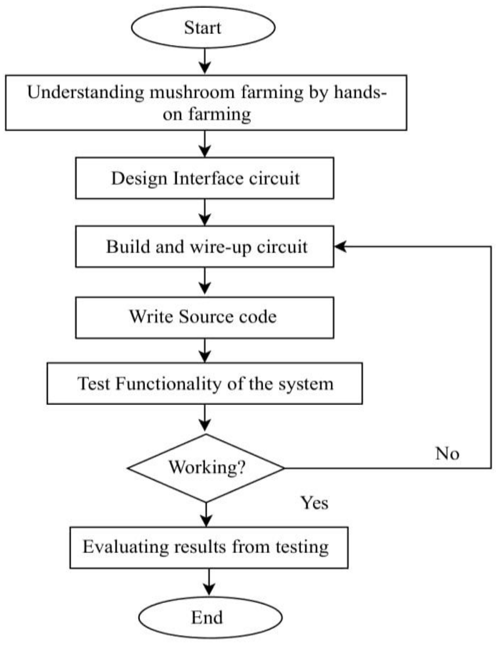

Fig 1:Methodology

2.2 BLOCK DIAGRAM

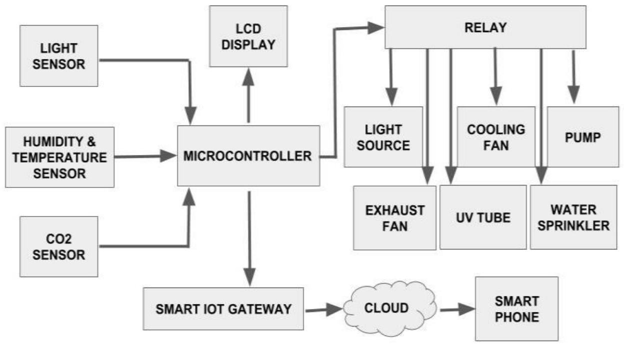

Fig 2: System Block Diagram

The system consists of two main parts: the sensing part and the control unit. The sensing part starts with data acquisition from the temperature and humidity sensor, carbon dioxide sensor and LDR (light-dependent resistor) using Atmega 328 microcontroller. The data is then sent to the Cloud. The graphs of temperature, humidity, carbon dioxide concentration and light intensity can be viewed using Adafruit.io. Adafruit.io is a cloud service - that just means we run it for you and you don't have to manage it. You can connect to it over the Internet. The control system includes processing data acquired from the sensors and controls appliances such and humidifier, fan and light to regulate the environment inside the mushroom farm according to the mode of environment selected. There are five modes of environment: which are essential conditions for Oyster, Milky, Button, Paddy straw and Shiitake mushroom. Different modes have different set of required environmental conditions as shown in Table 1.

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2.3 HARDWARE AND SOFTWARE

In implementing the sensing and actuating part, the mainly required parts are ATmega 328, DHT22, LDR, MQ-2, RTC, 8 channel relay, ESP 8266 WIFI module, 20*4 LCD Display, FTTI module, Water head, LED bulb, Water sprinkler, Exhaust fan, UV tube. Actually this is a master-slave system. Slave system comprises of the micro-controller and the sensing part and master system comprises of Wifimodule. The program starts with data acquisition from the temperature and humidity sensor, carbon dioxide sensor and LDR. Next, the control program enables the control system to take appropriate actions based on the data acquired to control and maintain the environmental condition in the mushroom farm at the desired condition. Then, the system transmits the data from the sensors to a

Type Of Mushroom	Temperature (Degree Celsius)	Relative Humidity (Percentage)	Light Intensity (Luminance)
Oyster Mushroom	20-30	55-70	300
Milky Mushroom	30-35	70-80	>100
Button Mushroom	16-18	85-90	500-1000
Shitake Mushroom	7-21	75-85	>100
Paddy Straw	30-38	57-60	>100

Table 1: Climatic conditions of different mushrooms

cloud for remote monitoring. The whole program is developed using ATmega 328. Data acquired from the sensors was monitored via Adafruit.io online interface. The first step was to sign up for a free account. Then, a new channel was created. In this project, four fields in the channel were used to record temperature, humidity, carbon dioxide concentration and light intensity. The channel was set to private and API keys were used to write data to the channel or read data from the channel. Data from the sensors was written to this Adafruit.io channel via ESP8266 WiFi module. Data stored in Adafruit cloud can be accessed anytime via WiFi connection. Embeded C is the programming language used and Eagle software is used for circuit implementation.

2.4 BLOCK DESIGN AND IMPLEMENTATION

2.4.1 Data Acquisition

The master ESP 8266 Wifi module request for the values from sensors. After data acquisition from sensors, data is sent to microcontroller where it is analysed and the controlling part components are turned ON based on the available data of a particular type of mushroom. And also the values of climatic conditions are displayed on LCD screen and through mobile phone.

2.4.2 Circuit design

The circuit board consists of three different sections. First section includes all sensors, Wi-Fi module and microcontroller in double layer in doted PCB board. The second section is LCD display which receives the values of climatic conditions from microcontroller and display it. Third section is 8 channel relay where the exhaust fan, water sprinkler, filter system, light are controlled by the microcontroller to maintain the desired climatic conditions.

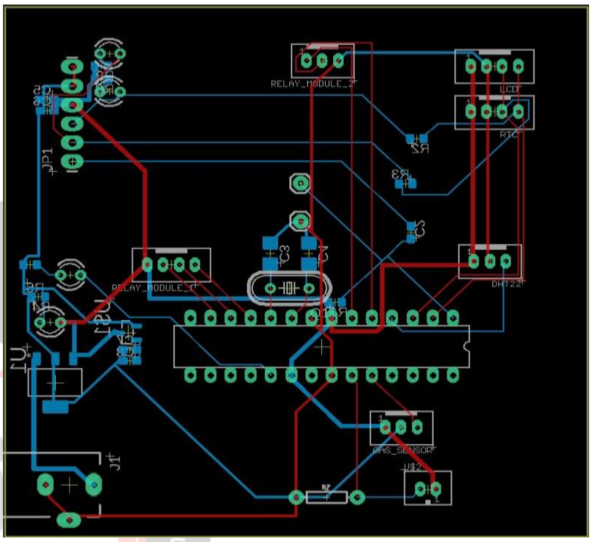

Fig 3 : Circuit Diagram

This circuit board is attached at the backside of the mushroom housing so that we can see the climatic conditions inside the housing at any time.

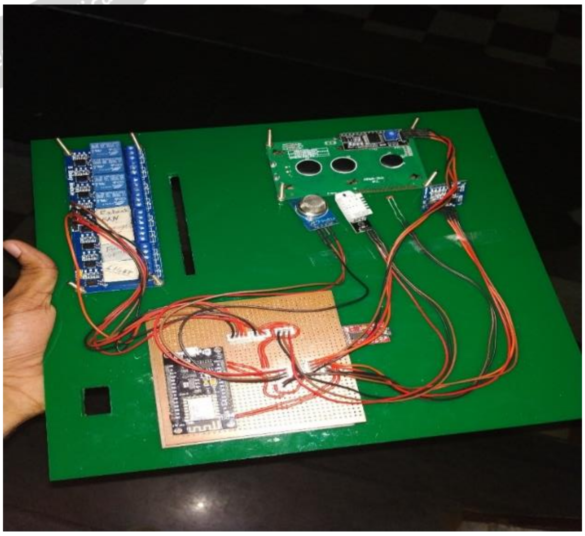

Fig 4 : Circuit Box

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Fig 5: Circuit Box(Outside)

2.5 MECHANICAL STRUCTURE

Fig 6 : PVC Structure

The housing is made for accommodating six beds at a time. The housing has (2m*1.5m*2m) dimension. The structure is made using PVC pipe, bend (L and T), PVC Coupling, silpolin grey opaque sheet and cable tie. The figure shows the initial PVC structure of housing.

Fig 7 : Mechanical structure

We have used high quality and toughest tarpaulin sheet called silpaulin grey opaque 100/200 GSM – 12’*10’. A door with dimension 0.8m*2m is attached in the front side of the housing.

The figure 8 shows the inside view of the housing. The filter system which includes exhaust fan, sponge and water sprinkler are connected at the back end. Water sprinkler to reduce temperature is connected at the top with in the system. Light source is also connected at the middle of the roof to get light equally all over the housing. The figure shows the mechanical structure which can accomodate six mushroom beds at a time .In our system we put four mushroom.

Fig 8 : Inside view of housing

III. RESULTS AND DISCUSSIONS

The result of our eight-month long effort is a High-Tech housing for sustainable mushroom cultivation. Using this year round production of any type of mushrooms at any climatic conditions are possible.

Fig 9 : Oyster mushroom

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This figure 9 shows white oyster mushroom from the housing. It took 27 days to get the output from the system. In first 21 days mushroom beds were kept in a dark room and after that light is automatically switched ON.

The table 2 shows the data collected from the system for 30 days. From this it is found that climatic conditions are controlled as per the requirements of specific type of mushroom. We have used Oyster type mushroom and the mushroom that we harvested got a light dark shade at the end of mushroom leaves. So we understood that the condition for temperature that is programmed for oyster type mushroom must be decreased from 30 degree celcius

Table 2 : Observations

CLIMATIC CONDITIONS INSIDE MUSHROOM HOUSING					
Date	**Time**	**Temperature (Celsius)**	**Relative Humidity (Percentage)**	**CO2 level (ppm)**	**Light intensity (Lux)**
16-Apr 2019	12PM	33	93	0.72	0.03
17-Apr 2019	9AM	29	85	0.81	0.04
18-Apr 2019	4PM	30	83	0.54	0.02
19-Apr 2019	3PM	31	68	1.32	0.03
20-Apr 2019	2PM	29	71	0.83	0.03
21-Apr 2019	11AM	28	65	0.91	0.04
22-Apr 2019	10AM	28	68	0.89	0.02
23-Apr 2019	9AM	27	63	0.78	0.04
24-Apr 2019	10AM	28	67	0.79	0.03
25-Apr 2019	11AM	28	69	0.9	0.04
26-Apr 2019	12PM	30	65	0.71	0.02
27-Apr 2019	2PM	29	68	0.69	0.03
28-Apr 2019	4PM	29	72	0.75	0.03
29-Apr 2019	6PM	31	71	1.08	0.04
30-Apr 2019	10AM	29	67	1.12	0.03
1-May 2019	12PM	28	69	0.76	0.03
2-May 2019	11AM	28	73	0.88	0.04
3-May 2019	11AM	28	68	0.89	0.03
4-May 2019	3PM	29	69	0.93	12.2
5-May 2019	6PM	29	67	0.92	12.2
6-May 2019	5PM	29	68	0.91	12.1
7-May 2019	4PM	29	69	0.89	11.9
8-May 2019	5PM	30	68	0.9	12.1
9-May 2019	12PM	29	69	0.93	12.2
10-May 2019	3PM	30	70	0.89	13.2
11-May 2019	2PM	30	75	1.1	13.6
12-May 2019	5PM	29	76	0.91	13.8
13-May 2019	9AM	31	78	0.92	13.2
14-May2019	10AM	30	72	0.9	14.7
15-May 2019	9AM	30	70	0.89	14.9

to 28 degree celcius. Mushroom takes 21 days for the germination of its seeds and after that it must be shifted to a light room. To ensure this, our system automatically switch ON the light source after 20 days and it can be inferred from the observation table. We have used an Incandescent bulb for the first one week and for the next week we have changed to LED bulb. So there we found a decrease in temperature value of the housing when LED is used.

Fig 10 : LCD Screen

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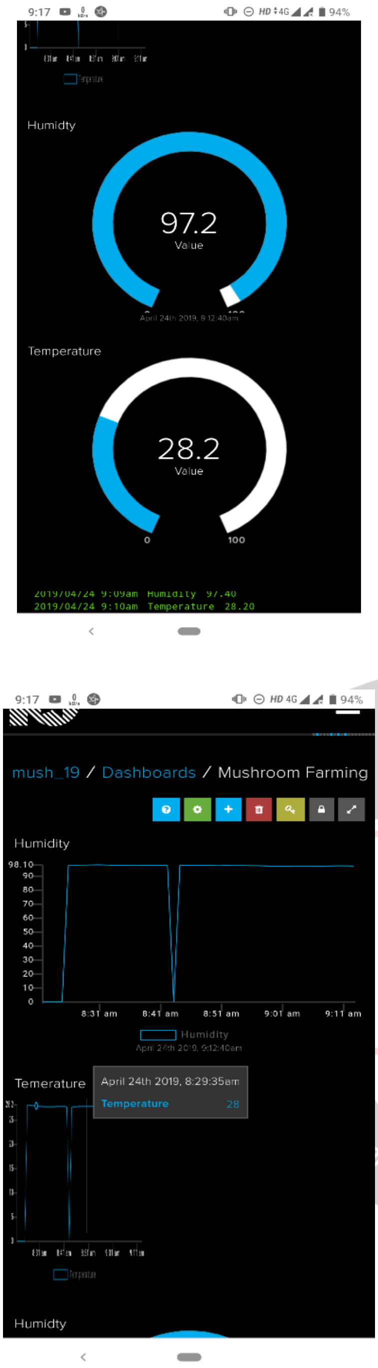

Fig 10 : Mobile screenshots

These are some screenshots and photos of the mobile data acquisition and LCD screen. We will get values in each one minute of interval. It can be represented in different forms like graph, meter view and there will be a tabular data of previous datas.

IV. CONCLUSION

Monitoring and environment control for indoor cultivation of oyster mushroom has successful been implemented. IoT based monitoring system is promising technology to enhance the production of mushroom due to low cost in capital because of system framework is based on open source platform. Easy and user friendly. Data migration is easy to be done. System is Expandable. The system can be modular, easy to increase the number of data/sensor. However, there are limitations on the system that need to be considered like remote monitoring is relying on internet connection quality. Currently, system control via internet is not recommended because of quality of internet. However it can be done with proposed system. Beside the hardware and internet data cost, operation cost (monthly/yearly) of server cloud platform must be taken account. Many platforms are free only for personal or non-commercial used and have a limited access. A data security issue in IoT is not a confidential. If the system deals with highly sensitive data, data verification or encryption method maybe needs to apply which is required a complex algorithm at server and nodes.

Future expansion of this system includes customisable and adjustable structure size. Selection of type of mushroom using mobile application can be done. Uninterrupted power supply to the system by providing batteries to avoid stoppage of controlling part during current failure. Usage of multiple modules for large scale production of different types of mushroom. Using coolers and heaters for faster controlling especially for certain types of mushroom.

V. ACKNOWLEDGEMENT

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