USING INTERNET OF THINGS FOR MONITORING AND CONTROL IN MUSHROOM PRODUCTION

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Abstract**—**For centuries, edible mushrooms have been cultivated, eaten and appreciated for their taste, medicinal value, economic and ecological benefits. In the recent past, production of mushrooms has been steadily increasing and it is expected that it will increase further in the future due to a corresponding increase in market demand.

The structures currently in use for the cultivation of mushrooms provide the optimum conditions for their growth. The qualities that farmers must pay attention to during cultivation of mushrooms include temperatures between 180C and 240C, relative humidity of above 75 per cent and optimum carbon dioxide levels at the different stages of its growth. The common trend among farmers is the use of manual forms of monitoring and control of the stated parameters which are not effective when large scale production is desired.

The rising demand brings about the need to have production of mushrooms on a large scale, and this in turn presents the problem of monitoring and controlling the aforementioned parameters. Manual methods prove inefficient for this purpose and therefore modern and automated methods become desirable. We propose use of a system that employs Internet of Things in monitoring, managing and control of the key parameters necessary for production.

The proposed system will consist of multiple sensors which will collect data pertaining to the parameters, feed the data to a processing system and eventually transmit the data for monitoring and controlling actions to be effected. The system will be capable to regulate and ensure the required temperature and Humidity is optimally maintained automatically. It is expected that the implementation of this system would aid in offsetting any discrepancies that may arise between the current conditions and the expected conditions in the mushroom cultivation structure.

Keywords**—**Internet of Things, Monitoring and controlling, Mushroom production, Sensors.

I. Introduction

MUSHROOMS are a fungus that occur naturally that have a fleshy appearance and reproduce by means of spores. They typically grow above the ground level on the soil or on their food source, which may be dead and decaying wooden logs or decaying organic matter. Some of the mushroom species are edible, containing several nutrients which have been shown to present the consumers with several health benefits, which include, but are not limited to: Decreased risk of obesity, increased mortality, reduced risk of heart disease, healthy skin complexion and increased energy [1].

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The most common method of mushroom growing is the use of a mud thatched structure. This structure is tuned so as to meet the various necessary growing conditions. On the floor, a level layer of crushed charcoal is poured [2]. This charcoal, when supplied with specific measures of water from external source on a daily basis, keeps the air in the structure humid and also maintains the temperatures within an optimum range.

It is important to note that this method used is largely manual, where the farmer will have to visit the structure to confirm the status of all the growth parameters and the integrity of the structure on a regular basis, which would be a tedious process should the farming be done on a large scale. Not to mention the fact that this constant visiting may tamper with the growth process, or contaminate the rooms used.

The use of IoT enhances the capability of the electronic equipment used in mushroom farming at by equipping them with the ability to communicate remotely and at the same time keep a record of the sensed data for analysis and further action influenced by the state of the data.

II. LITERATURE REVIEW

Mushrooms consist of some of man's earliest foods. Despite the fact that information concerning the origin of the cultivation and consumption of mushrooms is scanty, records trace it to the Chinese dynasty in 900BC. It is recorded that between 1678 and 1707, a method of artificial cultivation of the white mushroom, Agaricusbisporus, was developed [1].

Stemming from the Tang Dynasty (618-907 CE), mushroom cultivation has progressed from a crude art of placing steamed bran on logs and covering it with straw, to a precise science where optimized cultivation techniques maximize yields and increase quality [5]

With the analysis beginning at the Tang Dynasty, the methods of mushroom cultivation have evolved from being a primitive art, to a sophisticated and high precise science where optimized cultivation techniques are employed to maximize yields and increase quality. Modern cultivation technologies augment seven key stages of mushroom growth: These are spawn production and sterilization, spawn inoculation, substrate selection, substrate sterilization, climate control, mushroom harvesting and post-harvest transport. In high resource settings, advanced mushroom cultivation facilities consist of thermodynamically engineered systems in which temperature, pressure and relative humidity levels can be precisely altered to best facilitate growth in each stage of cultivation. The improvement of modern technologies such a technique for substrate sterilization and spawn preparation, computerized monitoring systems to control environmental parameters and automated harvesting systems have enabled mushroom growers in high resource settings to maximize production while minimizing cost.

However, in resource-constrained environments this type of precision and commercial production is not feasible due to the high capital investment, expensive operating costs and dynamic distribution channels that are required to sustain these systems. [2]

Because of the constraints mentioned, low cost solutions that are centered about IoT are proposed. IoT is defined as a network of physical and logical devices containing embedded technology to facilitate communication and interaction with their internal and external environment. IoT finds applications in the agricultural sector, especially when it comes to the control and monitoring of agricultural activities. The typical architecture of and IoT system is shown on Figure 1.

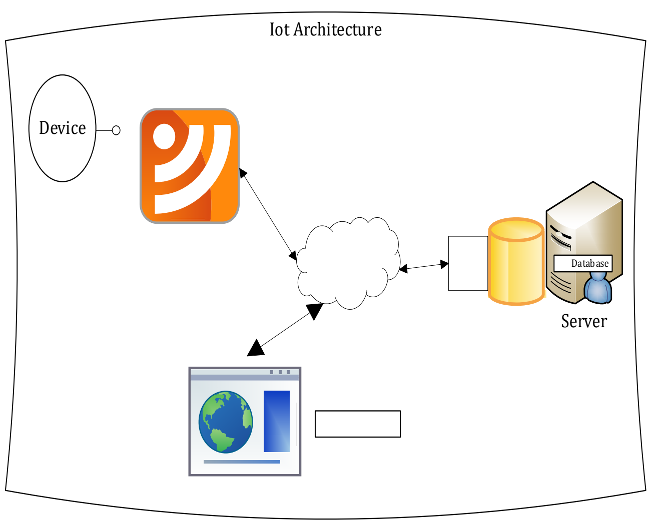

Figure 1: Typical IoT Architecture

In tropical countries, Kenya being one of such, with high temperatures most of the year, mushrooms don't easily grow. Farmers commonly cultivate mushrooms in plant houses in order to obtain the appropriate environmental conditions for growth. Although most of the mushrooms can grow well at a temperature range of 25-30ºC with humidity levels of above 80%, the optimum growth conditions are achieved at a temperature range of 16-22ºC. [1]

Due to the advancements in small scale sensor devices with wireless technologies, one is able to remotely monitor humidity, temperature and moisture [3].

Monitoring and controlling of the structure's environment parameters take place efficiently by use of both automatic and manual methods. The control room receives the status of the agricultural environment parameters from the sensors and is sent to the controllers. To monitor the values of the parameters which are continuously modified and controlled to achieve maximum growth and yield, microcontroller-based circuits are used [4]. Communication of the controller with the sensor modules results in controlling the parameters by actuating the respective components.

There have been a number of systems proposed in the past few years. One of them is a temperature and humidity monitoring system using AT89S52 as the microcontroller, SHT10 as the temperature and humidity sensor and TC35i GSM module for wireless communication. When the temperature and humidity exceed the limit, the system will send short messages to the mobile phones to alert the user [5].

The greenhouse monitoring and control is another system based on GSM. This system is more complicated when compared to the aforementioned system, as it not only allows for data acquisition, but for user-initiated parameter control as well by use of Short Messaging Service [6].

Another related project involved the automatic watering system that would use an electrode driven into the soil so as to monitor the amount of water in the soil surrounding the plants.

A system was then developed such that it would turn on a water pump when the level of water fell below what was ideal [7] [8].

III. SYSTEM DESIGN

To develop automatic control system of the room temperature, relative humidity, CO2 and light intensity of the mushroom growth control system, we use an Arduino Mega microcontroller. The sensors are placed within the mushroom structure and will transmit the detected result to the microcontroller. The Arduino Mega microcontroller is the main part of automatic control for this mushroom plant since it serves the purpose of setting the fan, humidifier and exhauster on and off [9]. The data is sent to the web platform on Thingspeak. The thingpeak.com module serves as a store for the data received from the sensor by the microcontroller and other necessary data. Figure 1 below is the block diagram of the system.

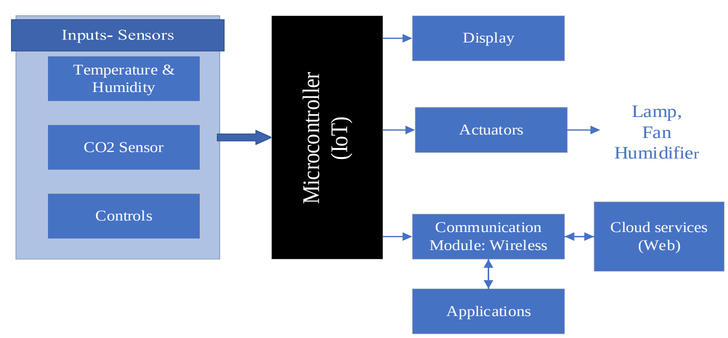

Figure 2-System Design

IV. METHODOLOGY:

In this system, we use the different sensors and a microcontroller for monitoring and a graphical user interface for controlling the parameters of the mushroom production. Data from the sensors is given as input to the microcontroller. After obtaining the data from the sensors, the microcontroller monitors it. The communication module enables communication between the two units.

In this system the structure consists of the Transmitter Section and Receiver Section. Transmitter section consists of sensory networks, which sense various parameters in the mushroom production structure. The various sensors used here are temperature, humidity and gas sensors. The output of the sensors is connected to an Analog to Digital converter (ADC) which transform the sensor output to digital format which is then processed using the microcontroller [7]. The microcontroller continuously monitors the sensors. The data is displayed in real time on a screen or monitor while it is also transmitted to the web for storage and further processing. When a parameter is perceived to be an anomaly, the personnel in charge are informed via SMS and at the same time the report is displayed on the screen.

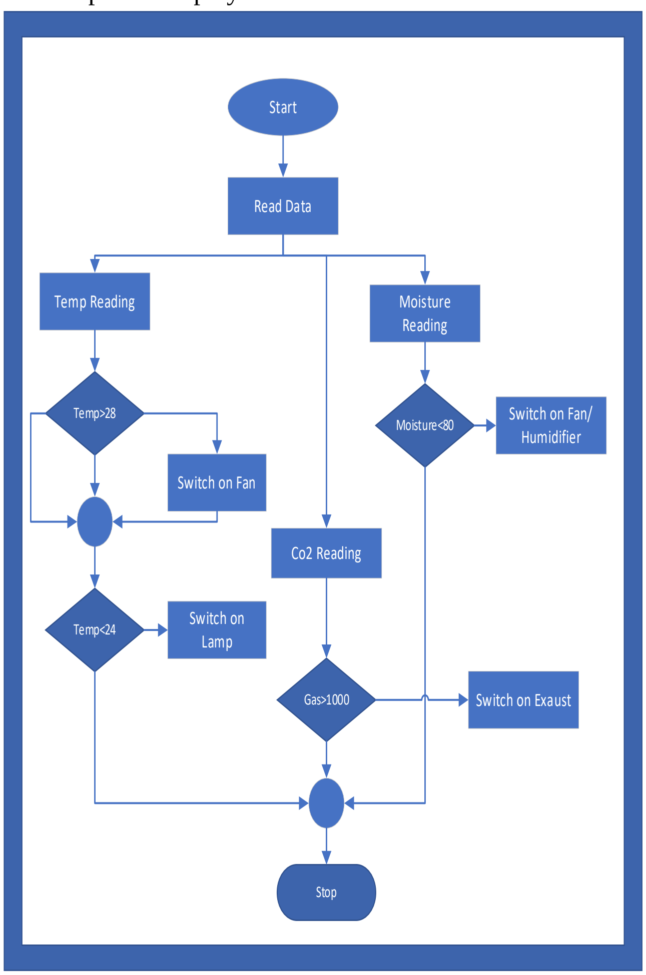

Figure 3- Flow Chart of the working of the System

The working process of the temperature control system and humidity is as follows; the temperature sensor will detect the overheating value of the mushroom area in units of the ° C range. If the temperature is more than 28ºC in the room, then this tool will turn on the humidifier and fan automatically to humidify and bring in air in order to lower the room temperature. When the temperature of the mushroom room falls below 22ºC, then the lamp will be turned on in order to heat the room to the optimum temperature [2].

The system flow begins with the detection of the temperature sensor. In the temperature sensor, if heat and humidity are detected, the fan and humidifier will ignite and do the condensation. And if normal temperature and normal humidity prevail, (22-28ºC) then the fan does not turn on, as well as cold temperatures and wet humidity then the fan also will not on [10]. The system flowchart is presented in figure 3 above.

In this project, Arduino Mega has been used as a controller to integrate data from the sensors and sends the information to the IoT platform through the GSM/GPRS module. Also, ThingSpeak has been used as an IoT platform. The sensor reading has been recorded to the series of parameters needed by the microcontroller through the connection of analog or digital input of Arduino Mega, then passing this data using serial communication to the GSM/GPRS module [9]. This GSM/GPRS module has been programmed to connect to the internet through HTTP commands, receive the sensor data from Arduino Mega and send the sensor data to the specific channel to the ThingSpeak IoT platform server using issuing provided HTTP API request format [3]. The successful data submitted can be visualized at ThingSpeak IoT platform.

When the system prototype was set up the temperature and Humidity obtained were as the figure 4 shown below. These results are uploaded to ThingSpeak platform where the graphical analysis is done as shown in figure 5 below.

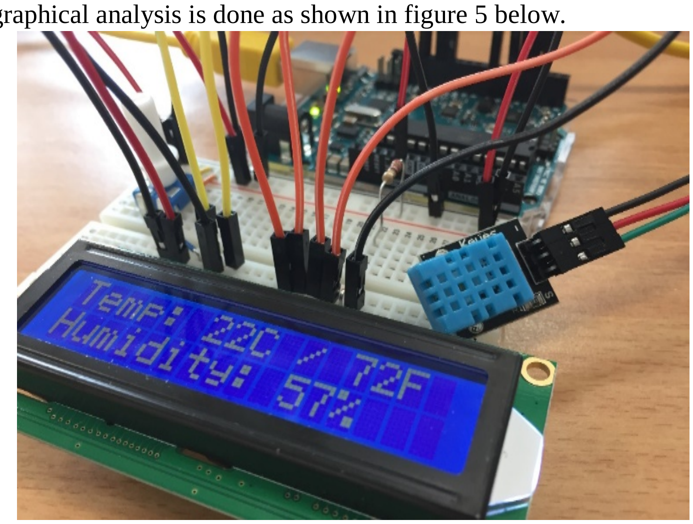

Figure 4- Results of the Prototype on Temperature and Humidity of a room

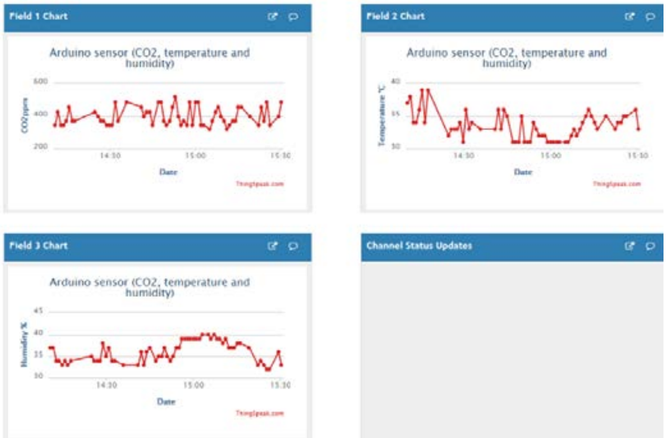

Figure 5- Graphical Representation from ThingSpeak on Temp, Humidity& CO2

CONCLUSION

The proposed IoT based control system was designed and implemented. Testing was then carried out, which involved installation of the fabricated prototype in the mushroom growing structure. The testing involved exposing the system to conditions that were normal, and later to conditions that were outside the normal range, and the response of the system was observed. It was noticed that when presented with abnormal data, the system initiated the expected corrective response within a short time of the sensors picking up the data. The system therefore met the objectives set for it.

Implementation of this system would aid in monitoring and ensure little attention is required since the processes are achieved automatically. This will give room for the farmer to do engage in large scale mushroom production without fear.

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