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Development of Web-based Smart Monitoring System using IoT & Mobile Application for Grapes Drying Unit

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Abstract

IoT (Internet of Things) is one of the leading technologies that is used in many fields and departments. This IoT technology has made the working of systems easier and more hassle-free. This IoT is having tremendous usage and application in the agricultural fields making farmers' life easier. This IoT technology is used for automation in the agricultural fields to monitor various parameters in real time, helping the farmers in yielding good crops. One such smart system used to safeguard raisins from the climatic changes has been proposed in this research. The drying of grapes requires specific temperature and humidity to be maintained to attain good yield. There is always a possibility of sudden unexpected rains, and it would be difficult for the people to close the sheds of such large drying units and also it is a time-consuming process. In such cases, this model is used where the sheds automatically get closed with the help of the motors and input from the rainfall sensor. Also, additional features such as flame alarm and buzzer module, which help in detecting the fire and informing the farmer about the danger to take immediate action, are used. All these controlling and monitoring are done by making use of the IoT technology and the WSN.

Keywords: IoT Technology, Smart Agriculture, Wireless Sensor Networks, Security Control System, Real-Time Data Monitor

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1. Introduction

Grape is an important fruit crop grown in the agriculture farming sector. The final product of the raisins depends on the quality of the process of drying the grapes with proper parameters maintained. The grapes harvested from the fields are sent for consumption and some are sent for the drying process and are converted to raisins, which also increases the shelf-life. Dried grapes (raisins) that are rich in minerals & vitamins, have the potential to improve human health [3]. The quality of raisins may vary due to the impact on the duration of dried, sugar concentration, enzyme activity, etc. In traditional drying such as open sun drying, the grapes are laid on single layer on racks, wood or plastic trays exposed to natural air and the sunlight in shed buildings. To prevent the rotting of raisins due to climatic changes, the farmers must make use of the technologies such as IoT and WSN. By using modern sensor & sensing technology, the variability in the drying process can be identified, quantified, and controlled for improving quality & productivity of the dried grapes. Field information collection could be achieved by low-cost and low-energy consumption sensor nodes deployment (wireless sensor networks) [5].

This research has designed & developed a system for remote monitoring & collection of real-time data for control dehydration unit in the drying process. In view of current intelligent drying process, the proposed system consists of a series of peripherals placed inside the drying structure, which are equipped with sensors for environmental monitoring. Control requirements are related to equipment and traditional (ZigBee, Wi-Fi, GPRS) wireless sensing technologies. This model uses various sensors for the complete detection of environmental parameters and implements the control strategy for optimal result. In this research, additional features are included for flame/smoke detection, remote access for entry of authorized person for security, energy management, etc.

2. Literature Survey

A web-based smart monitoring system using IoT, and a mobile application can enhance the efficiency of grapes drying units [1]. The system can help in monitoring and controlling the temperature, humidity, and airflow during the drying process. A literature survey can provide valuable insights into the existing technologies and approaches used for developing such systems. IoT-based smart drying systems have been developed for various food products, including fruits and vegetables. In these systems, the environmental conditions are monitored using sensors, and the data is transmitted to a cloud-based server. Machine learning algorithms were enabled to monitor as well as predict the information and provide outputs into the drying process. Some examples of such systems are:

a) A smart drying system for mushroom drying based on IoT and artificial neural networks was developed by Li et al. (2019). The system used temperature and humidity sensors to monitor the drying process and provide real-time feedback to the users [6].

b) A smart drying system for Chinese herbs based on IoT and big data analytics was developed by Zhang et al. (2017). The system used temperature, humidity, and airflow sensors to monitor the drying process and provide predictive analytics for optimizing the drying process.

3. Architecture of the Model

The implementation analysis of web-based smart grape drying module is developed by integrating Node- Microcontroller Unit (MCU), IoT environment with mobile application and sensor network. Figure 3.1 shows the architecture of the proposed model for dehydration units & security system. The model is developed with user friendly environment for farmers for monitoring the applications. The system model placed in the grape drying shed, monitors the statics of the dehydration unit & other required data for control & monitoring application. Further, all these sensor data are uploaded based on IoT environment in addition to automatic shed covering system that is used to protect from the rainfall and for safety purpose [8]. The model uses a Node-MCU microprocessor, some input sensors and output sensors. The communication of these sensors is done through the IoT technology and Wireless Sensor Network, where the information data is analyzed with reference to the standard required information, and the output actuators are performed accordingly.

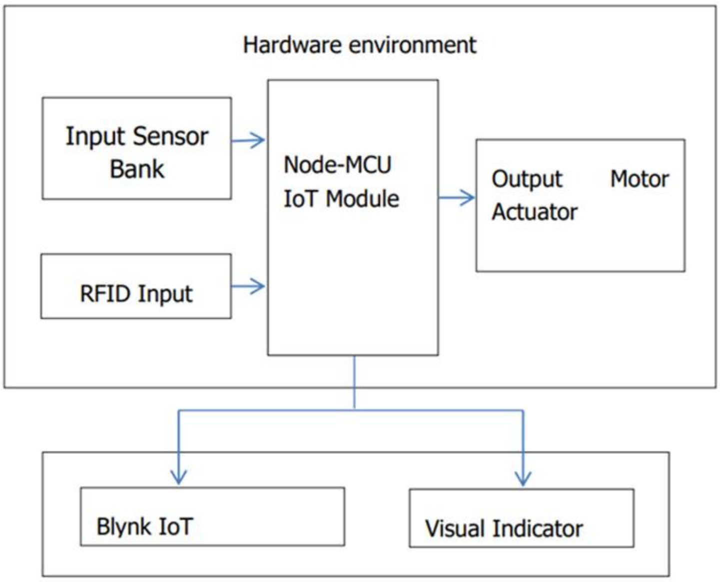

Figure 3.1. Architecture of the proposed model

3.1. Block Diagram

The block diagram shown in figure 3.1 is a general square chart of the Arduino based ESP8266 IoT module, a programmed safeguarding framework which comprises of four sensors which are associated with controller [2]. The detected readings from these sensors are sent to the portable applications. Rain sensor detects the cloud and sky condition air velocity, temperature, and other variables. This sensor senses the cloud and oncoming rain and sends the instructions which will be used by the shed unit that will applied for automatic shed opening and closing. The fire sensors are used to detect the fire in the shed, and in case the fire is detected, the buzzer will be turned ON otherwise it will be OFF. The RFID card reader is used for the entry and exit of authorized person in order to avoid the theft during the absence of the owner for security purpose. The 7805 regulator is used maintain the constant 5V across the circuit, and Light Detecting Resistor (LDR) sensors are used to turn ON and OFF the light. If the sunlight is present, the LDR remains OFF and in the absence of the sunlight the LDR will be turned ON.

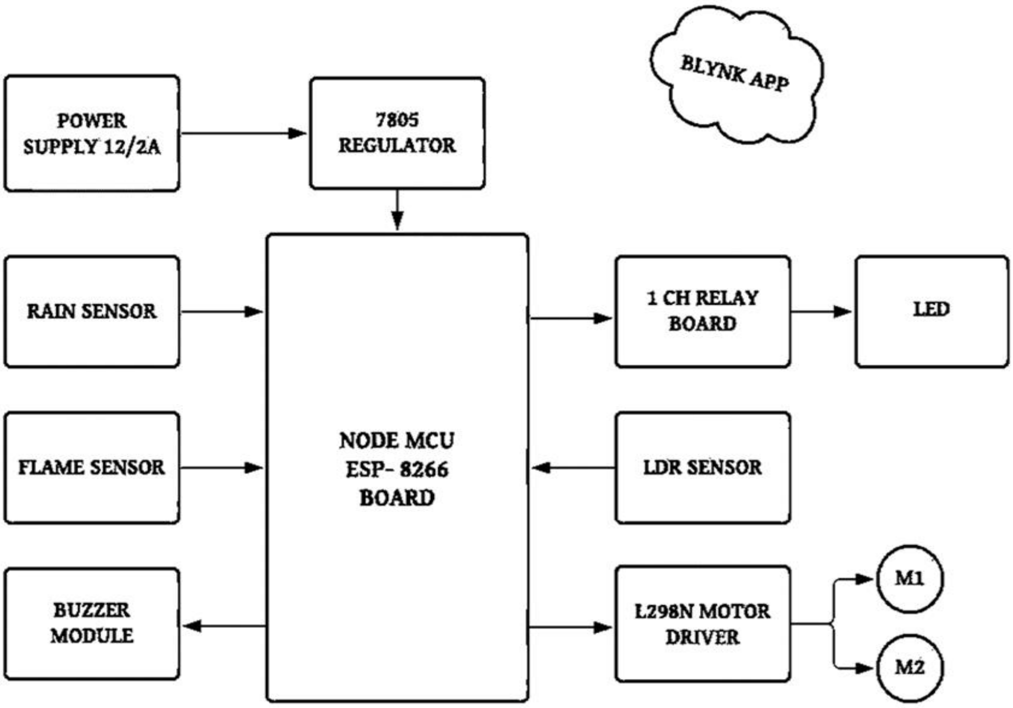

Figure 3.2. Dehydration Shed Control System Block Diagram

The grapes drying shed unit comprises od several sensors and devices which are interconnected through the network and makes use of the microprocessor Node-MCU. There are two categories of components: hardware and software.

3.2 Hardware Description

The hardware components include Node-MCU, temperature and humidity sensor, rainfall sensor, flame sensor, LDR and a buzzer module.

3.2.1 Node MCU (ESP-32)

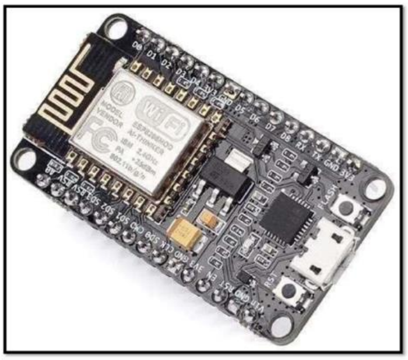

Figure 3.2.1. Node MCU (ESP 32S) Controller

Node MCU is an open-source firmware and development board based on the ESP-32 microcontroller. It provides an easy-to-use platform for developing IoT applications and is ideal for projects that require Wi-Fi and Bluetooth connectivity. The ESP-32 microcontroller given in figure 3.2.1 is a powerful and low-cost device that supports a range of features, including dual-core processing, Wi-Fi and Bluetooth connectivity, and multiple communication protocols such as SPI, I2C, and UART. Node MCU provides an easy-to-use platform for developing IoT applications using the Lua programming language. The Lua scripting language is lightweight and easy to learn, making it an excellent choice for beginners who are new to programming. Node MCU boards come with built-in Wi-Fi and Bluetooth connectivity, making it easy to connect to other devices and the internet [7]. The board also includes a range of GPIO pins, allowing users to connect a range of sensors and other peripherals to their projects. Node MCU is supported by a large and active community, which has developed a range of libraries and resources to help users get started with their projects.

3.2.2. Light dependent resistor

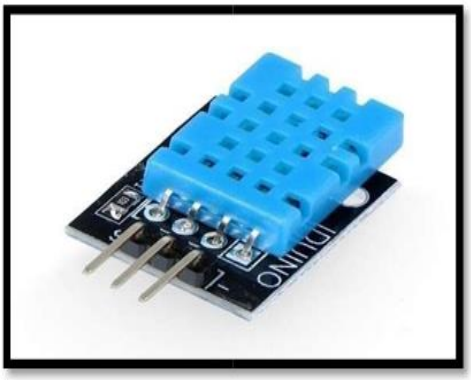

Figure 3.2.2. Light Dependent Resistor

LDR shown in figure 3.2.2 is just another special type of Resistor and hence has no polarity i.e., they can be connected in any direction. They are breadboard friendly and can be easily used on a performance board also. The symbol for LDR is just as similar to Resistor but adds to inward arrows [10]. The arrows indicate the light signals. A photoresistor or LDR, as the name suggests will change its resistance based on the light around it i.e., when the resistor is placed in a dark room, it will have a resistance of few mega ohms and when light is gradually imposed over the sensor, its resistance will start to decrease from mega ohms to few ohms.

3.2.3. Temperature sensor and humidity sensor

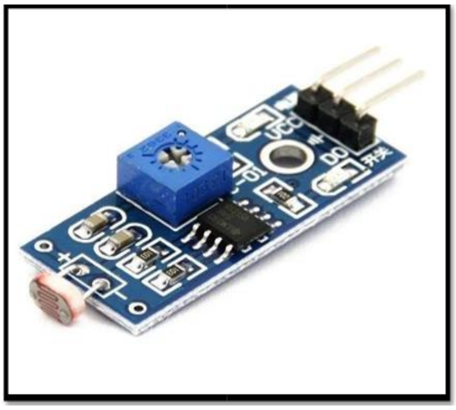

Figure 3.2.3. Temperature and humidity Sensor

It consists of a thermistor and a humidity sensor, both of which are integrated onto a single chip, along with a signal processing circuit. The DHT11 sensor shown in figure 3.2.3 is designed to provide accurate temperature and humidity readings in a range of environments. The sensor communicates with a microcontroller through a single digital pin, making it easy to use with popular platforms such as Arduino and Raspberry Pi. The data is transmitted using a simple communication protocol that includes start and stop signals, as well as a checksum to ensure data integrity.

3.2.4. Rain Fall sensor

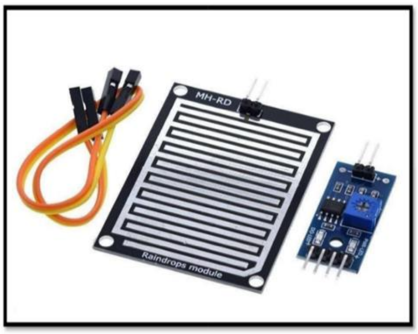

Figure 3.2.4. Rain Fall Sensor

The rain sensor module shown in figure 3.2.4 is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board, and also for measuring rainfall intensity. Raindrop sensor is a tool used for sensing rain [9]. SKU-16883 is a specific model of a rainfall sensor. However, without additional information, it is difficult to provide specific details about this sensor. In general, rainfall sensors like SKU-16883 typically work by measuring the amount of water that falls onto a surface area. The sensor may use various methods to detect the rainfall, such as capacitive or optical sensing. Some sensors may also include additional features, such as temperature compensation, to improve accuracy.

3.2.5. Flame Sensor

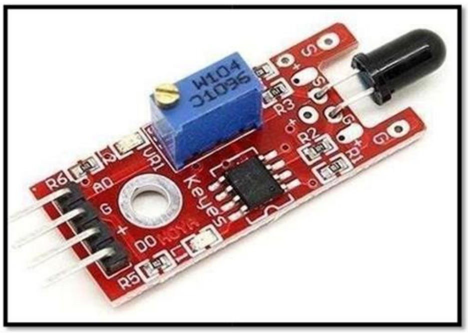

Figure 3.2.5. Flame Sensor

A flame sensor that is shown in figure 3.2.5 is a device that is used to detect the presence or absence of flame in a combustion process. It is commonly used in gas-fired furnaces, boilers, and water heaters to ensure that the flame is present and is burning properly. Flame sensors typically use an infrared detector to sense the heat and light emitted by the flame. The detector sends a signal to a control system, which can then adjust the flow of fuel to maintain the proper flame. If the flame sensor detects that the flame is not present or is not burning correctly, it can trigger an alarm or shut down the system to prevent a dangerous situation, such as a gas leak or fire. Flame sensors are an important safety feature in gas-fired appliances, and they are required by industry standards and regulations. They help to ensure that the appliance operates safely and efficiently, and they can prevent serious accidents or damage to property.

3.2.6. Buzzer Module

A buzzer module is an electronic device that produces an audible sound when an electric signal is applied to it. As shown in figure 3.2.6, it typically consists of a piezoelectric element that vibrates when a voltage is applied, creating a sound wave that can be heard.

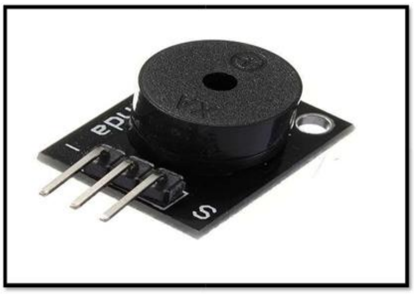

Figure 3.2.6. Buzzer Module

There are different types of buzzer modules available, including passive and active buzzers. Passive buzzers are simple devices that require an external oscillator circuit to produce a tone, while active buzzers have an integrated oscillator circuit and can produce a tone with just a single input signal.

3.3 Software Requirements

The software components used here are the IoT technology, Blynk Application, and the Arduino IDE.

3.3.1. Blynk Application

Blynk is a popular mobile application that allows users to remotely control and monitor their IoT devices through a simple and intuitive user interface. The application is designed to work with the Blynk cloud platform, which provides a range of tools and services to connect IoT devices to the internet and enable communication between them. The Blynk application allows users to create customizable dashboard interfaces that display data from their IoT devices, such as temperature, humidity, and sensor readings [12]. The application also provides a range of widgets that can be added to the dashboard, such as buttons, sliders, and gauges, to create custom interfaces for different types of IoT devices. Users can also create alerts and notifications based on the data collected by their IoT devices, such as receiving an alert when a temperature threshold exceeds. Blynk supports a wide range of IoT platforms and devices, including Arduino, Raspberry Pi, ESP8266, and Particle. It also provides an API and SDK for developers to integrate Blynk functionality into their own applications and devices.

3.3.2. Arduino IDE

Arduino IDE, or Integrated Development Environment, is a software platform used to program and develop applications for Arduino microcontroller boards. Arduino IDE provides a simple and user-friendly interface that allows users to write and upload code to their Arduino boards quickly and easily. Arduino IDE also includes a library manager, which provides access to a wide range of libraries and examples that can be used to add new functionality to Arduino projects [11]. These libraries include pre-written code that can be easily added to Arduino projects, allowing users to incorporate complex functions such as Bluetooth connectivity, sensors, and displays, quickly and easily. Arduino IDE supports a wide range of Arduino boards, including the popular Arduino Uno, Nano, and Mega, as well as many other boards based on the Atmel AVR and ARM Cortex-M processors.

3.3.3. IoT Technology

IoT, or the Internet of Things, refers to the network of physical devices, vehicles, home appliances, and other items that are embedded with sensors, software, and connectivity, enabling them to connect and exchange data over the internet. The IoT technology allows for the seamless integration of physical devices and the digital world, enabling the collection and analysis of data, and automation of processes [13].

IoT technology comprises of four key components, namely sensors, connectivity, data processing, and user interface. Sensors are embedded in the physical devices to collect data such as temperature, humidity, pressure, and motion. Data processing involves the analysis and interpretation of the data collected by the sensors using cloud-based platforms, machine learning algorithms, or other analytical tools. Finally, the user interface provides a means for users to access and control the IoT devices, typically through a web or mobile application [14].

4. Methodology

A “Smart Raisin Management” can be accomplished using three units namely,

• Dehydration Unit

• Shed Unit

• Security Unit

4.1 Dehydration Shed Control System

Simulation model for the dehydration shed control system is shown in figure 4.1. After the harvesting of the grapes from the fields, some of them are sent for consumption and the remaining for the drying process, where they are dried, and raisins are formed. The quality and color of the resins depends on the sugar content level present in the grapes. The selected grapes are washed and cleaned and then is subjected to the dehydration process [4]. Naturally it takes 20 days to dehydration by maintaining the temperature (if temp >33, the fan will be ON). By keeping the temperature constant, the humidity will increase. Thus, the dehydration process will be done in 12-15 days.

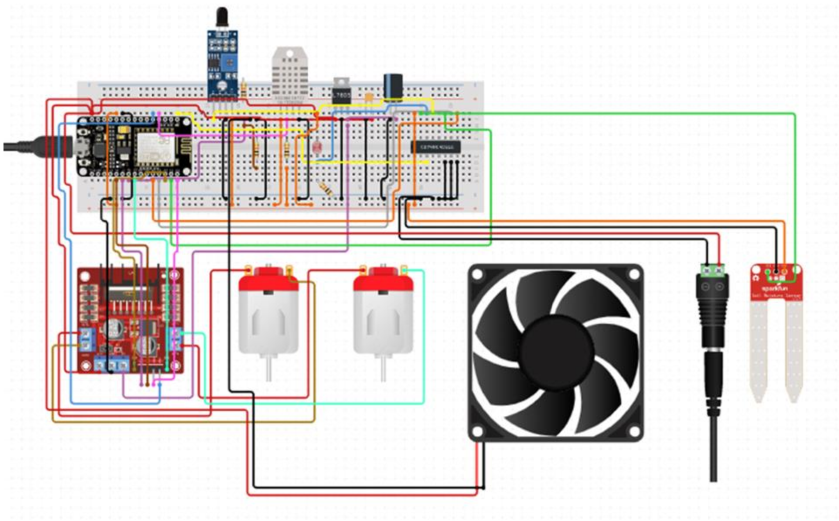

Figure 4.1. Dehydration and Shed Unit Circuit

Shed Control System used here has the main function to cover the shed automatically when there is unexpected rain. The rain sensor detects rain and sends the message to the ESP-8266. The processor will control the opening and closing operation depending on the condition. There are additional features being used to maintain and control the desired conditions such as humidity and temperature.

4.2 Security Unit

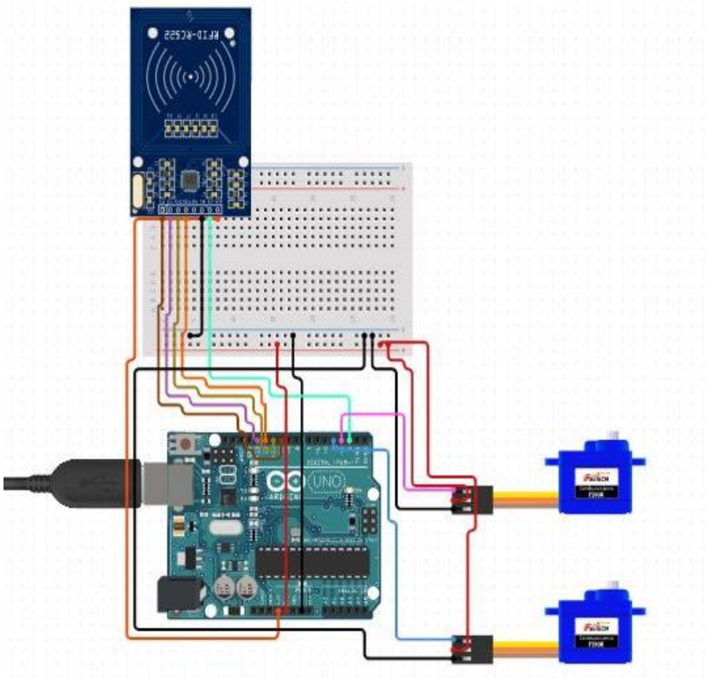

Figure 4.2. Security Unit Circuit

The simulation model for the security unit is shown in fig. 4.2. In the Security Unit, RFID card is connected to the Arduino board. This is mainly used for the security purpose to avoid thefts. The RFID card will only allow the authorized people to enter the shed i.e., the gate will be open with help of servo motor, and the unauthorized people will not be able to enter the shed.

4.3 Final Grapes Shed Unit Model

The research model shown in figure 4.3 consists of microcontroller and sensors such as temperature sensor, rainfall sensor, flame sensors. These sensors are used to monitor the real-time data and take relevant actions. The rainfall sensor detects the rain and makes the two stepper motors to run, to automatically close the shed. Also, an alarm and buzzer module are used to alert in case of fire emergency. The complete monitoring system provides status of the drying process, quality of the product & environmental information. By adapting automation technique, the production rate can be increased & the wastage can be reduced. The model that is prepared is a prototype of the grapes drying shed unit with layers inside them where the grapes are arranged properly. The rainfall sensor and the two stepper motors are interconnected together, so when there is a sudden unexpected rainfall, the shed can be automatically closed.

All the parameters within the shed control system can be monitored and controlled by the cultivator from a remote location.

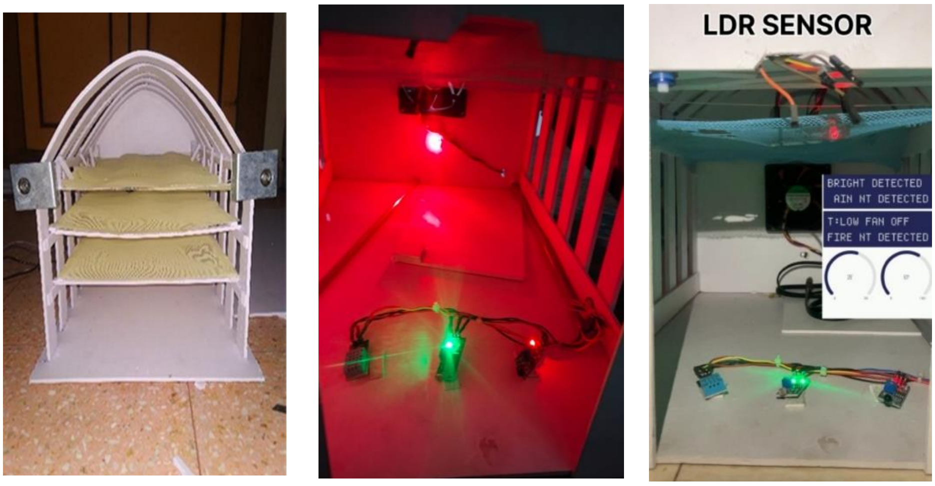

Figure 4.3, Hardware model of the dehydration shed control system

5. Results

The model has the main function of automatically closing the sheds in case of unexpected rains. The information data collected by the input sensors is given to the Node-MCU, where it processes the data and drives the output actuators accordingly. The below shown figure 5.1 is the snapshot of the notification in Blynk application that is displayed containing information about the weather condition. The temperature and humidity section determines the temperature and humidity level in the atmosphere.

a. The statement “Fire not detected” represents the detection of fire.

b. The statement “Darkness detected”/ “Bright detected” represent the output from LDR.

c. The statement “Rain detected” represents the condition of rain.

d. The temperature and humidity section, determines the temperature and humidity readings.

e. Each of the two OFF buttons represents the controlling of LED.

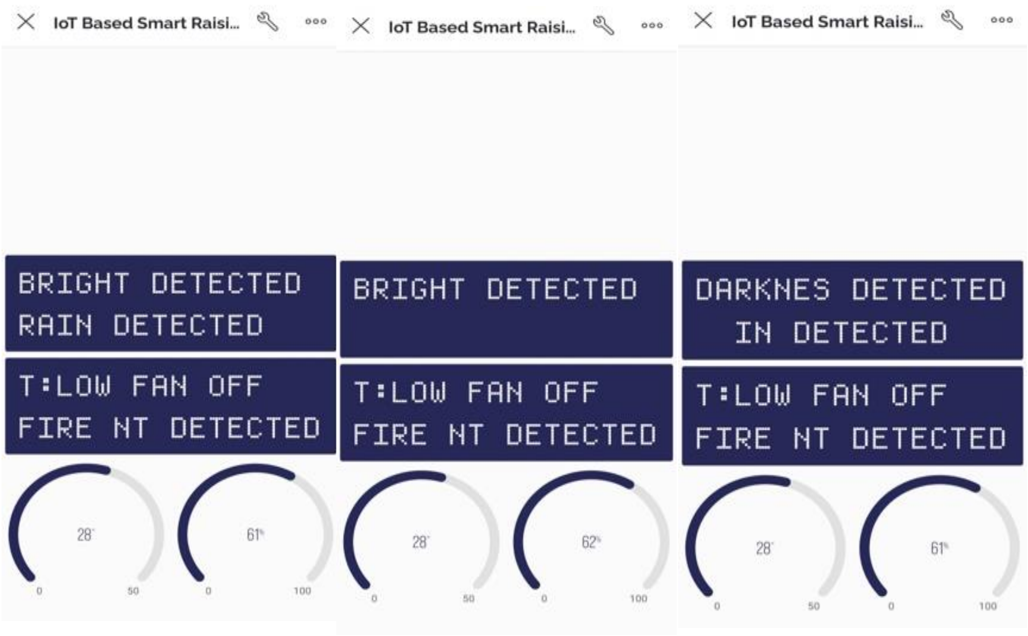

Figure 5.1. Snapshot of Blynk Application with alert message notification

6. Conclusion

The IoT has occupied a predominant space in almost all fields due to its efficiency. As agriculture monitoring system is needed to reduce the need for human intervention in farming, this study has introduced the IoT in monitoring the pretreatment of raisins. By using this model, it is possible to maintain the suitable conditions required for the raisins, by safeguarding it from environmental factors like rain, high temperatures, fire, or trespassing. This smart shed model used can significantly reduce the drying period from 20 days to 15 days.

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