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Research Article

Development of Fragaria Monitoring System by Intelligent Control Using Raspberry Pi 3

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Abstract

Strawberries produced in greenhouses under highly controlled environmental conditions are expected to contribute to a stable supply of agricultural commodities regardless of the weather. Meteorological parameter measurement is critical for adjusting to environmental conditions. A computerised framework is designed to control the environment in a greenhouse efficiently. On the other hand, strawberries are difficult to grow in a greenhouse unless given proper care and attention. The most significant drawback of greenhouses is that they need more manpower. Furthermore, as strawberries are sensitive to soil moisture, soil moisture monitoring is required to ensure timely watering. Sensors are used in automatic irrigation systems to measure soil moisture. Based on the soil's moisture content, the sensor sends a signal to activate the water valve. To measure the environmental quantities such as temperature, humidity, and pressure, we developed the Fragaria Monitoring System due to experiments and studies to resolve the current system's deficiencies. This study set out the key difference between FMS and current greenhouses because it allows fully integrated environmental management within a container. By continuously monitoring the plants' condition and initiating adjustments to provide maximum optimal growth, this device decreases the amount of work needed to grow plants.

Keywords
Strawberries Monitoring System; Intelligent Plantation System; Raspberry Pi 3 Module B+; Green House; Homegrown Strawberries.

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Introduction

Agriculture is an important contributor to the national and local economies. Increased agricultural production and productivity tend to contribute significantly to a country's overall economic growth. As a result, proper farm management is necessary for an investor to benefit from its overall appreciation. Since Malaysia is predominantly an agricultural country, it constantly strives for higher agricultural production and growth. In terms of strawberry production in Malaysia, most strawberry farms in Malaysia are located in Cameron Highland, also known as the "Strawberry Fields of Malaysia." Strawberry is a valuable crop in the region, and the Strawberry Festival is held every season to celebrate it. Strawberry farming is a significant and integral part of the local economy. As a result, high strawberry production and quality are of primary concern.

One of the most important factors in ensuring good production and profitability of strawberry plants is proper watering [1]. Watering properly results in large plants with large leaves, which produce more flowers, which produce more fruits. Strawberries are particularly vulnerable to drought. During periods of active growth, frequent and proper watering is needed for good root growth and maximum nutrient availability. In this regard, watering must be done at the right time so that the soil does not get too dry or too wet [2]. The strawberry plants' ability to get enough water at the right time depends on careful monitoring of soil moisture. Plants that grow in cold climates vary from those that thrive in temperatures below 27°C. The average temperature is between 10-20°C. The humidity level is between 70-80% [3]. Due to this potentiality, many researchers have focused on the Fragaria Monitoring System (FMS) ability to eliminate workforce performance in monitoring specific strawberry issues. This system enhances the capability of home gardeners to produce exquisite homegrown strawberries. It enables monitoring of the environment inside a container, thus reducing the workload required to grow plants compared to the existing system by constantly monitoring each plant's condition and initiate adjustment to provide full optimal growth. FMS is more effective and efficient than the greenhouse due to the use of sensors and dedicated equipment to monitor and alter certain variables such as temperature and soil moisture.

Table 1
Comparison between FMS and Existing System.

Current Greenhouse System (Ladang Kokhas)	**Fragaria Monitoring System**
Requires constant monitoring, maintenance and care from manpower	Capable of monitoring the environmental condition via an LCD screen
Time-consuming to detect or fix environmental conditions issue	Can monitor multiple environmental conditions at one time using hard-wired sensors
No user interface	Offers a user interface on an LCD monitor
Transparent plastic cover built over greenhouse area. A plastic cover is prone to rips and tears. Relatively short lifespan and requires replacement.	The structure is made from acrylic, which is stronger than normal glass. This makes it much more impact-resistant and safer.

The table above shows several features that can be compared in terms of the control system, reliability, and requirements. Eventually, FMS is superior to the current method as it is more convenient and user-friendly for both full-time and part-time gardeners. In terms of application, this framework eliminates all of the heavy lifting associated with plant care by allowing users to monitor or correct any mistake in the monitored variables through a graphical user interface (GUI) rather than correcting the issues manually. Since the system works ecologically, it is fair to assume that this system is environmentally friendly. Organic farming promotes soil and water protection and emission reduction in the air and water [4]. The plants' surrounding conditions will be shown as data on an LCD touchscreen display interface. The device provides the real-time value and alerts the user about the time to start monitoring the plants and the container's humidity level. The FMS allows users to manually or automatically monitor and correct any condition inside the container using an LCD display. Using FMS, gardeners or strawberry lovers could grow strawberries in any location outsides of Cameron Highlands and monitor their growth. Since all of the work can be performed from the users' fingertips, no manpower is needed on-site to track or adjust the environmental quality to an acceptable level. This paper proposes a new methodology for developing a monitoring system in planting strawberries that will determine a real-time performance in terms of temperature, soil moisture, and humidity by using a Raspberry Pi 3 microcontroller. Besides, this paper focuses on analysing the algorithm's ability to compute FMS for fixing an error through GUI without manually handling it. The implementation of monitoring real-time data associated with the LCD display algorithm will be highlighted.

Material And Method

The FMS has several features that set it apart from other greenhouse monitoring systems. Users may use the LCD screen to monitor the environment and condition. When the machine starts up, it looks for sensor output signals. The device will compare the real-time temperature and soil moisture level to the optimum value. Besides, the humidity sensor module detects the current value. Following that, information about the system will be displayed on an LCD screen, then plant control operations will begin. If the environmental condition reaches or falls below the set level, monitoring of the equipment's variables could be manually or automatically activated or deactivated at the users' discretion.

Hardware Design System

In general, the microcontroller is one of the main components controlling the system. In this case, the Raspberry Pi 3-V1.2, as shown in (a), is used. All of its sensors are included in the diagram to ensure the high performance of the monitoring system. The model of the electronic is usually represented by a simplified equivalent circuit model, as indicated in (b)

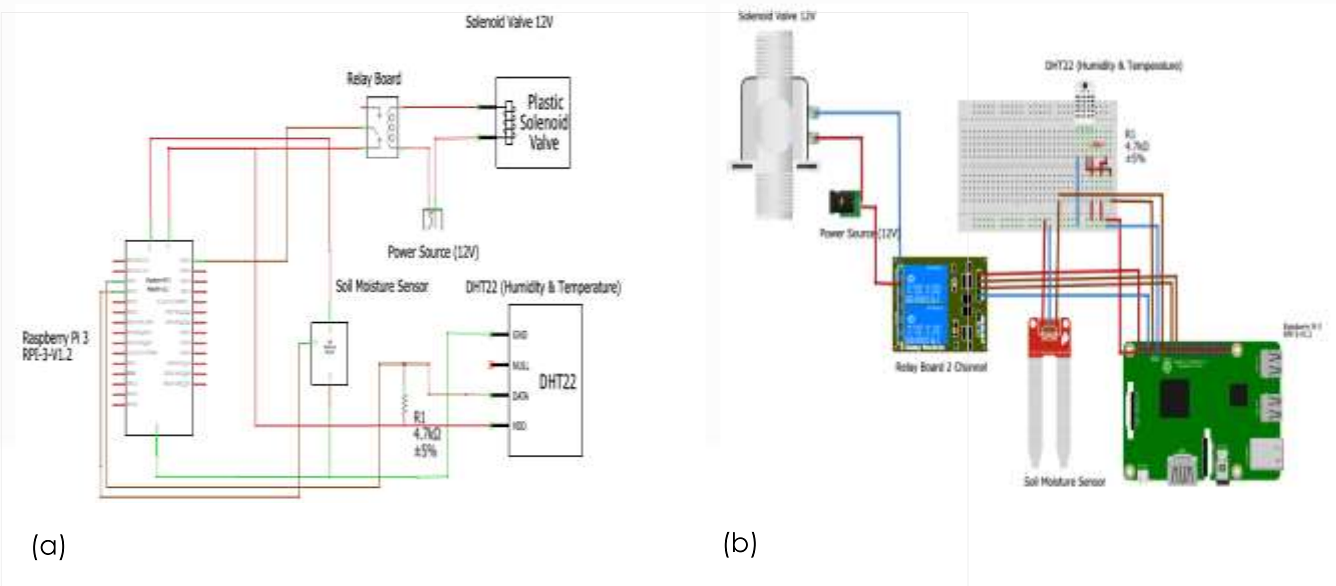

Figure 1 Drawing of Circuit Diagram for Hardware. (a) Modelling for Electrical Design, (b) An Illustration of Electronic Components.

The selection of all components is categorical. It is based on the criteria that the users have to meet based on the Perpetual Strawberry type. The Raspberry Pi 3 B model was used as it supports all the FMS needed. Its specifications include Broadcom BCM2837 64bit ARM Cortex-A53 Quad Core Processor So C running @ 1.2GHz. 1 GB RAM. 4 x USB2.0 Ports with up to 1.2A output. Expanded 40-pin GPIO Header. Video/Audio Out via 4-pole 3.5mm connector, HDMI, CSI camera, or Raw LCD (DSI). Storage: microSD. 10/100 Ethernet (RJ45). BCM43143 WiFi onboard. Bluetooth Low Energy (BLE) on board. Low-Level Peripherals: 27 x GPIO, UART and I2C bus. SPI bus with two chip selects. +3.3V to +5V. Power Requirements: 5V @ 2.4 A via micro USB power source. Supports Raspbian, Windows 10 IoT Core, Open

ELEC, OSMC, Pidora, Arch Linux, RISC OS and Dimensions: 85mm x 56mm x 17mm. The DHT22 type with the input of 3.3-6V, measuring current of 1-1.5mA and the standby current of 40-50 uA was used to measure the temperature and humidity. The humidity ranges from 0-100% RH while the temperature ranges between -40 - 80 degrees C, with the +-2% RH accuracy and +-0.5 degrees Celsius. Meanwhile, there are two parts in the Moisture Sensor Module, the sensor probes and a module board. The sensor is made of two probes that will be inserted into the soil. It uses the two probes to pass current through the soil to measure the resistance based on the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly (more resistance). It is easy to use with a power supply ranging from 3.3V to 5VDC and current of ~ 35mA.

The Irrigation System

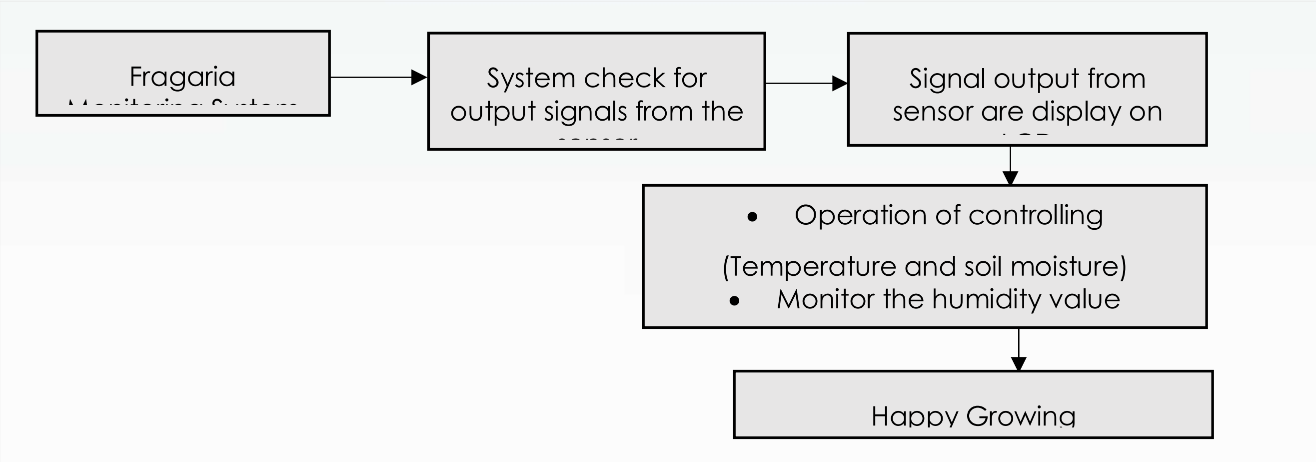

Figure 2 Conceptual of Framework

The precise use of drip irrigation provides an ideal soil moisture level for plant growth. The irrigation time interval depends on the rate of water evaporation, temperature, the stage of plant development, and the drip tube's flow rate. The irrigation interval starts short and increases as the plant develops and the temperature rises [5]. The water demand is greatest during the fruit setting and fruit sizing stage. Thus, at this time, the soil needs to have an ideal soil moisture level to obtain high yields of high-quality fruits. Growers who are using drip irrigation for the first time are encouraged to water by a set schedule. Within time, the growers will be able to fine-tune the irrigation schedule to their fields [6]. Growers should check their fields every 2 or 3 days to determine if the time intervals for irrigation need to be increased or decreased. Strawberry cultivars vary widely in size, colour, flavour, shape, degree of fertility, season of ripening, liability to disease, and plant constitution [7-10]. The automated temperature and humidity control system for strawberry plantation will highlight the control of the system's temperature and the soil's moisture by using PIC 16F877A. The reduction of the required temperature will adjust by the cooling system when the sensor detects any changes from the surrounding. The moisture of the soil control by the humidity sensor. In this regard, when the soil is dry, the water pump will automatically pump water to the soil. These two factors are very important to maintain the quality of strawberry fruits.

Implementation

The ideal temperature for strawberry growing is 15°C to 26°C, with the relative humidity of 65% to 75 % is considered optimum. Strawberries prefer a "loam" soil, a type of soil made of equal amounts of clay, sand and silt. Strawberries prefer slightly acidic soils with a pH of between 5.5 and 6.5. In this light, a bed should only be watered after flowering, and a water sprinkler should be used once every two weeks to apply 50-75 litres of water per m². We decided to use an air conditioner as a medium to control the temperature. Horsepower needed to cool a room is determined through this equation:
Horsepower (hp) = width ×length ×BTU.

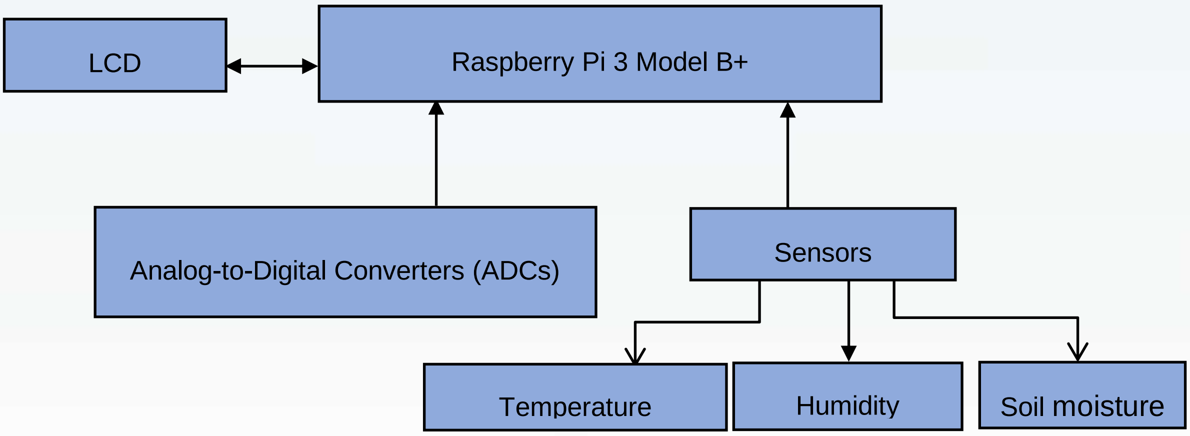

Figure 3 System Architecture

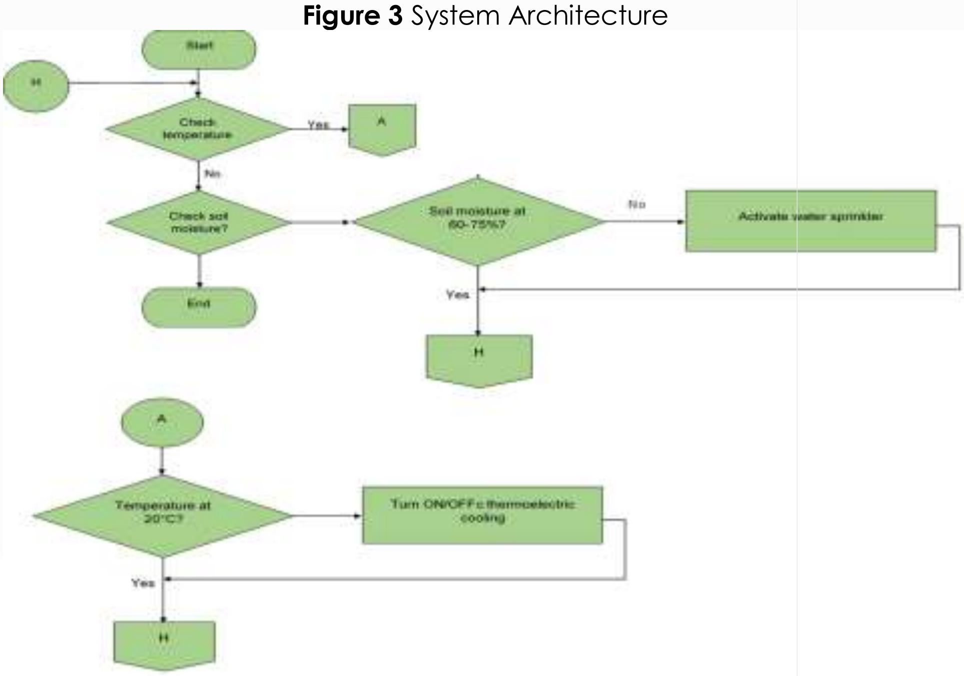

Figure 4 Flow Chart

The system's procedure begins with the power supply being turned on, followed by scanning the LCD's sensor outputs. All of the controlled variables can be monitored at the same time using the GUI. Furthermore, a few concerns emerged during the project's implementation, which we successfully resolved with our vulnerabilities. A countermeasure is a reaction to an adverse event or circumstance. The structure of our product, which is made entirely of acrylic glass, was also sagging. We solved the problem by inserting ribs on all sides to keep the acrylic in place. Acrylic glasses are also vulnerable to scratches and harm from certain solvents. Cleaning acrylic glass with isopropyl alcohol avoids this.

Finally, the system's wiring is too similar to the irrigation system, which may result in a short circuit. As a result, a terminal box to load and secure all the wirings was set up as a security feature for consumers.

Result

Full-scale experiments were carried out in the GMi laboratory, where FMS would monitor temperature, humidity and control the soil moisture in real-time. Figure 5 shows the result of our monitoring system. Our project structure includes an acrylic container, strawberry plant, cooling system and other wirings in the system.

Figure 5 Field Test of Fragaria Monitoring System. (a) A general Overview of the Framework, (b) Close-up Structure inside the Container

Figure 6 shows the result of GUI that displays the real-time temperature and soil moisture inside the container between 60% -75% for strawberry to get the proper growth. There is also a display to initiate the controlling medium for watering the plant automatically or manually and activate the cooling system.

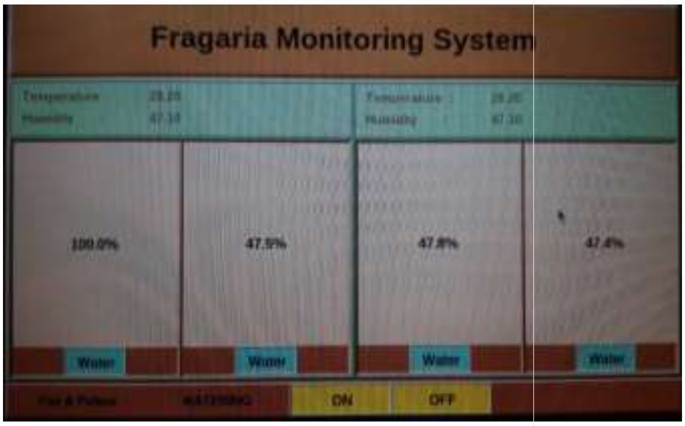

Figure 6 Monitoring System in Real-Time
As shown in Figure 7, the algorithm is used to monitor and control dependences based on the specification facts of the processes. These structures contain not only control but also data correlations, which are crucial for programme slicing.

Algorithm: Temperature &Humidity;

1st Compartment:

```
firstlbltemp = Label(LITFrame, font=('arial',11,'bold'), text="Temperature :", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
firstlbltemp.place(x=10, y=5)
firstlblhum= Label(LITFrame, font=('arial',11,'bold'), text="Humidity :", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
firstlblhum.place(x=10, y=30)
firstlbltemp1 = Label(LITFrame, font=('arial',11,'bold'), text="temperature", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')firstlbltemp1.place(x=160, y=5)
firstlblhum1 = Label(LITFrame, font=('arial',11,'bold'), text="humidity", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
firstlblhum1.place(x=160, y=30)
```

2nd Compartment:

```
secondlbltemp = Label(RITFrame, font=('arial',11,'bold'), text="Temperature :", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
secondlbltemp.place(x=10, y=5)
secondlblhum= Label(RITFrame, font=('arial',11,'bold'), text="Humidity :", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
secondlblhum.place(x=10, y=30)
secondlbltemp1 = Label(RITFrame, font=('arial',11,'bold'), text="temperature", bg='pale green', fg='sienna4', width=14, height=1, anchor='w')
secondlbltemp1.place(x=160, y=5)
secondlblhum1 = Label(RITFrame, font=('arial',11,'bold'), text="humidity", bg='pale secondlblhum1.place(x=160, y=30)
```

Soil Moist ADC: Hardware SPI Configuration:

```
SPI_PORT   = 0
SPI_DEVICE = 0
mcp = Adafruit_MCP3008.MCP3008(spi=SPI.SpiDev(SPI_PORT, SPI_DEVICE))
def readmoist():
   global sm1s, moist_reading1,moist_reading2,moist_reading3,moist_reading4
   sm1 = mcp.read_adc(0)
   moist_reading1 = (sm1 * 100) / float(1023)
   moist_reading1 = round(moist_reading1, 1)
   lblsoilmois1.configure(text=str(moist_reading1) + "%", anchor='center')
   sm2 = mcp.read_adc(1)
   moist_reading2 = (sm2 * 100) / float(1023)
   moist_reading2 = round(moist_reading2, 1)
   lblsoilmois2.configure(text=str(moist_reading2) + "%", anchor='center')
   sm3 = mcp.read_adc(2)
   moist_reading3 = (sm3 * 100) / float(1023)
   moist_reading3 = round(moist_reading3, 1)
```

```
    lblsoilmois3.configure(text=str(moist_reading3) + "%", anchor='center')
    sm4 = mcp.read_adc(3)
    moist_reading4 = (sm4 * 100) / float(1023)
    moist_reading4 = round(moist_reading4, 1)
    lblsoilmois4.configure(text=str(moist_reading4) + "%", anchor='center')
```

Automated Watering Function:

```
def watering():
    sm1 = mcp.read_adc(0)
    if sm1 <= 700:
        lblautowater["text"]='WATERING '
        lblautowater.pack(side = LEFT)
        relay_on(1)
        time.sleep(5)
        relay_off(1)
    elif sm1 >=1000:
        lblautowater["text"]='         '
        lblautowater.pack(side = LEFT)
```

Timereading:

```
def read_every_second():
  READ1()
READ2()  readmoist()
  watering()
  root.after(3000, read_every_second)
read_every_second()
root.mainloop()
```

Figure 7 an algorithm for the FMS process flow

Conclusion

The intelligent monitoring system in the strawberries greenhouse designed based on FMS has been completed. The success of the field test means that strawberry plants can be cultivated all over Malaysia, not just in Cameron Highlands. This study has constructed a monitoring system for strawberry planting in a container using a Raspberry Pi 3 microcontroller. The system keeps track of temperature, soil moisture, and humidity to allow effective and efficient temperature and soil moisture control for strawberry cultivation. Furthermore, by using a relay to switch on or off the cooling unit, the device maintains the optimal temperature for strawberries at 20°C. A Graphic User Interface (GUI) with an LCD monitor was installed to control the container's moisture content by triggering a solenoid valve. Since it allows users to monitor or fix any error through a GUI rather than manually patching the error, the system takes entirely heavy lifting out of caring for the strawberry plant. Users could use the LCD monitor to control the temperature within the container in a variety of ways. The research and application of theories in completing this project results in the Fragaria Monitoring System, which is useful to ensure the cultivation and harvest of quality strawberry fruits. Therefore, this study makes a major contribution to research on strawberries grow by demonstrating Fragaria Monitoring System by using intelligent controller.

Recommendation

In this age of advanced technologies, this study suggests using other means to monitor or modify the

Fragaria Monitoring System. Rather than using LCD, future designs could use more user-friendly devices such as mobile phones with a browser. Mobile devices, for instance, are easy to carry around and are most people's first choice of device, especially among millennial gardeners. Finally, the number of gutters could be increased so that our system can monitor a wider range of plants or vegetables, such as chilli, one of the most common plants for home gardening. All of the issues raised aim to enhance the method, the content, and the overall quality. This study infers that the improvement of the product could give it a higher commercial value in industries.

Acknowledgement

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