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Development of Smart Incubator Grow System For Plant

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Abstract. In the current industrialized food production network, most food suppliers rely on large, mono-crop farms that grow massive amounts of a single product and ship it around the globe. Food may travel thousands of miles over the course of days, weeks, or even months before it reaches our tables. Not only is this system strain on the environment, and on the cost to the consumer, but it also affects the quality of the food we put in our bodies. The objective of this project is to design and develop a smart incubator grow system for plants by developing the open source hardware and software platforms for sensor-controlled hydroponic and aeroponic agriculture systems. Inside of this smart incubator, climate variables such as carbon dioxide, air temperature, humidity, dissolved oxygen, potential hydrogen, electrical conductivity, root-zone temperature, and more can be controlled and monitored. Usage specifications such as operational energy, water use, and mineral consumption can also be monitored and adjusted through electrical meters, flow sensors, and controllable chemical doses throughout the growth period. The complete set of conditions throughout a growth cycle produces unique phenotypic expressions, or physical qualities in different plants. Plants grown under different conditions may vary in colour, size, texture, growth rate, yield, flavour, and nutrient density. The system can be monitor and control through wireless connectivity technology

1. Introduction

In this modern era, farming seems no longer as an individual hobby, routine and side income. This is due to a few reasons which is plants need a constant observation and monitoring, meticulous care and make sure it produces healthy crop [1]. Therefore, it needs a lot of time, cost and energy as a commitment. Smart incubator grow system for plants one of new kind technology and innovation which help industry or individual to obtain a better result for farming. Furthermore, this incubator is user friendly which is easy to handle, manage and maintain [2]. This incubator control PH, mineral, light, air temperature, and humidity to form an optimal environment for plants.

An embedded system is a computer system with a specific function to integrate with all the sensors, hardware and mechanical parts, often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. The advantage of smart incubator grow system for plants are managed to avoid fungus and bacteria which is harmful for plants, reduce the consumption of energy and water, and increase the productivity of product in short term without spoil[3]. Moreover, this incubator can be monitored and handled via cell phone through the application. The hardware and software have been connected and installed. Typically farming problem is they cannot supply the demand of food from consumers because farmers can't control the environment [4]. By the time it reaches our tables, it has often travelled thousands of kilometres. In addition, this product will be less fresh and nutritious. Produce on demand food nowadays is important [5]. Furthermore, planting a plant in farm tend to be attacked by bacteria and infected by disease. Unhealthy plant, are exposed to the air which bring the bacteria and disease. The condition of



environmental cannot be controlled because the plant will face various types of weather, environment and natural diseases [1], [5], [6]. Farming sector required a lot of workforce. The objective of workforce is to monitor the plant, control the mineral, and control the nutrient due to obtain the best result for the crop. This is a waste of cost, energy and time. There are always happened wasteful fertilizer in order to handle and maintain the quality of plants. Therefore, this will increase the cost to overcome the waste of fertilizer. The plant care must be done manually, which requires more workers, time and energy.

Basically, smart incubator has sensors to integrate with the hardware such as temperature, humidity, ion, and light intensity. Those sensors, led and hardware are connecting with microcontroller or single board computer. There are numerous special I/O functions found on modern microcontrollers [3]. In a nutshell they include hardware interrupt, analogue, external reset, switch denouncer and input pullup. Farming in building is new method to grow a plant, however it faced a lot of problems such as light intensity, temperature and nutrient resources [4], [7]. To overcome this problem, smart incubator system come with wireless technology system. This will help to control, monitor and handle the growing plant. Furthermore, smart incubator system will full fill the demand on industry and consumer to have product in shortage time length than normal. This article is based on MIT's incubator which hold key to food crisis [5].

In smart incubator, there are several factors that affect this system such as the quality of air, the optimal temperature, humidity and light in order to produce quality and healthy crop. As for air, air circulation is extremely important as the main agent to produce food. Plants use carbon dioxide from the air to manufacture sugars. Furthermore, plants need oxygen for respiration after photosynthesis [7], [8]. The next factor to be considered is the temperature, there is an optimal temperature for the plant to accomplish photosynthesis. If the temperature is not suitable, plant will grow slower due to either condition being too cold and slowing the rate of chemical reactions inside plant cells, or becoming too hot, which denatures enzymes and causes cell death [6]. Next, there is another factor which affects the growth of plants which is nutrients. Nutrients type are divided into two parts, which are micronutrient and macronutrients. Macronutrients consists of nine types of nutrients while micronutrient has seven of them [9].

Suggestion for improvement smart incubator grow system for plants, will be applied on microcontroller or single board computer. The system will monitor everything that your plants need to grow, including light, ventilation, nutrient levels and pH of the soil. The control will be done by the wireless technology. This will occupy the demand on farming sector

2. System proposed

This project consists of five modules that work together to accomplish the task. The system starts with acquires data of surrounding and soil. Then the data will be interpreted in meaningful data in binary form through a slave subsystem before transport the data over the master sub system. The master sub system processes the data received and make decision before gives a command through the actuator to control the condition of surrounding. At the same time, the master sub system updates the collecting data from slave onto the database. This database system enables the farmer or user system to acknowledge the current status of their crop and the current condition of incubator in everywhere by access their smartphone. This monitoring online system give availability the user to control their crop from apart by giving the command through the application on their smartphone. This smartphone has connected and accessed to the embedded server in order to acquire latest data collected.

Figure 1.0 below shown the block diagram of essential elements for the development of smart incubator system grow for plant. Those elements contained of sensor which integrated to Arduino microcontroller board. This stage used the Arduino board to receive the voltage level input from the sensors. Then those voltage level converts to understandable value then in binary value by referring the datasheet given by sensor provider. This interpretable data received by master or Raspberry Pi board via cable connection to control and activates the LED, pH stabilizer and nutrient pump in the

incubator. At the same time, the Raspberry Pi or the single board computer use to update the collected sensor data to the server via online transmission. Those data are used for display the current information of crop on accessible device such as handphone.

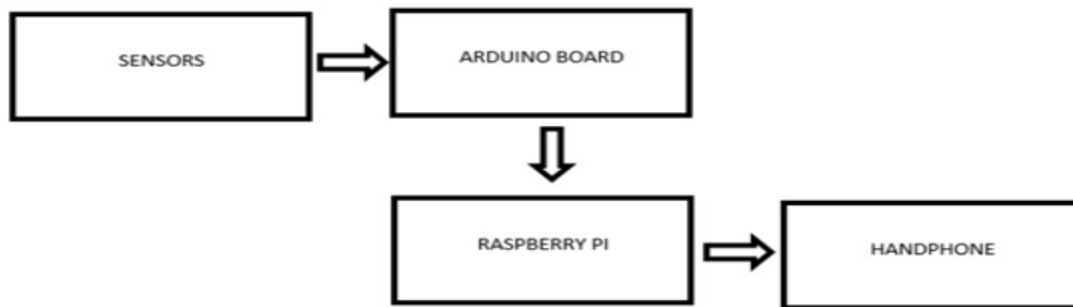


Figure 1. The block diagram of the basis component.

The Figure 1 is a block diagram of a smart incubator system grows for plants shown as above. There are 2 different sensors has been integrated in this work, which each of them has tasked to monitor some parameter as an indicator of the condition of plant inside the incubator. The Figure 2 shown the sensors are used to measure the temperature, humidity, and pH inside the incubator. Those parameters are crucial and need to be monitored and controlled in order to ensure plant in perfect condition and suites with their environment.

As we know, the sensor senses the signal of environment in an analogue signal form and convey the produced output signal in an analogue voltage form. Then this signal transfer directly to the Arduino microcontroller through assigned pin input. The data converts into meaningful signal and transform in binary data before passed all of them to the Raspberry Pi board computer for data analyzation. Both of the board act as slave sub-system (Arduino Board) and master sub-system (Raspberry Pi Computer) configuration. In this part of both master and slave are connected via wirelessly. After that master sub-system makes a decision and action to control the plant condition via giving the command back to the slave and control his actuator.

The information and signal that obtain from the slave sub-system will trigger actuator to manage the nutrient management and LED rays inside the incubator. Furthermore, the master board collected the pH, temperature and humidity data has to keep the data on the database through the communication device. Moreover, the embedded server has the interface application for the system which connect to the single board computer and hand phone through wireless. As a result, the environment inside the incubator available to be monitor via mobile phone.

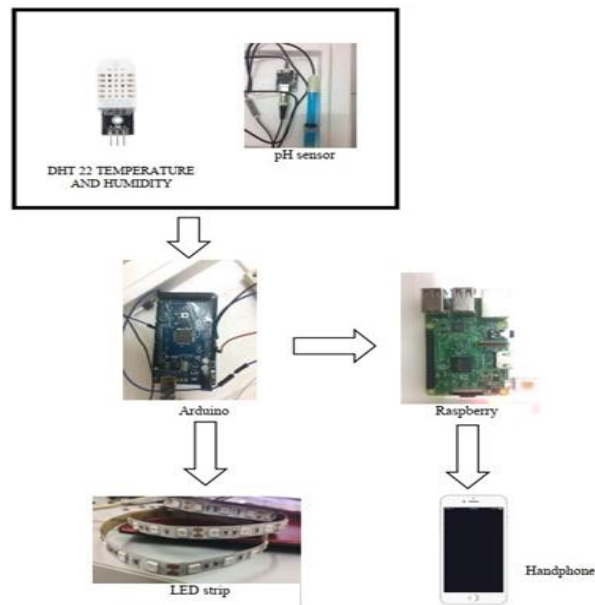


Figure 2. Combination of components in this work

Figure 3 shows a model of Master and slave communication where one device or process has unidirectional control over one or more other devices. In some systems a master is selected from a group of eligible devices, with the other devices acting in the role of slaves. This project has been applied and implemented with this concept. Arduino play a role to collect and obtain data from the environment and produce the output via the instruction from the raspberry Pi which act as a master board and server. Furthermore, the code has been written and programmed on the Arduino and Raspberry Pi in order to integrate and communicate between to board. This coding and programmed can be viewed through the VNC Arduino IDE.

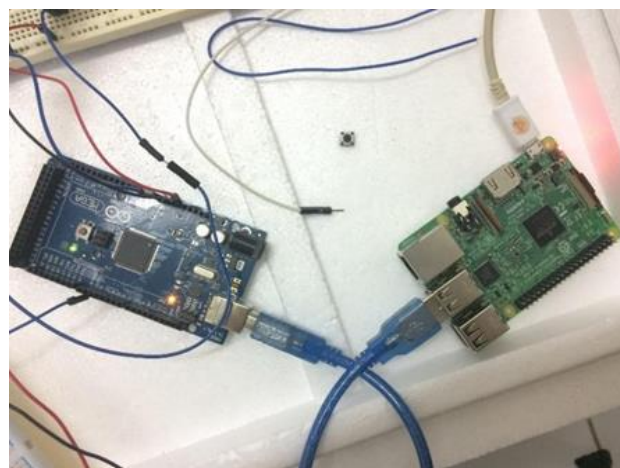


Figure 3. Integration of Master and Slave communication

3. Result and Discussion

This section is discussed about the results obtained by measuring the data of PH, humidity and temperature from the various sensors. The result is obtained by measuring the output from the sensor with connection to the slave device. This measurement done by interpreted the analogue signal to meaningful signal by the slave. This method is applied in order to make the tracing process easier and debugging process can be done precisely.

At the same time the LED strip is deployed on the indoor system in order to control the light ray which act like sunlight when the outdoor environment. Furthermore, the light ray will be turn on along 6 hours then it will be turned off for the next 2 hours. This system using a master and slave concept where the terminal on master device is connected wirelessly to the slave device and monitoring them. Initially both devices need to display a unique key or data that has been transmitted during communication process. Both devices have been programmed and installed with all required data and file to ensure the communication can develop without any error. Last but not least, VNC present as a medium to run and show data in real time environment. This show, communication environment between application and current system.

3.1. Data acquisition from the DHT22 sensor

The humidity and temperature data are acquired by using the DHT22 sensor. This sensor device connected to the server via Arduino and Raspberry Pi. Where the Raspberry Pi act as a server where collecting all those data in real time before updating them on online server or cloud. Table below show the output in different humidity and degree of Celsius in every 30 seconds.

Table 1: Humidity and temperature data recorded

Humidity	Temperature (C)
79.40	27.90
79.50	27.80
79.60	27.70
79.80	27.70
80.30	27.60
80.20	27.50
80.70	27.40

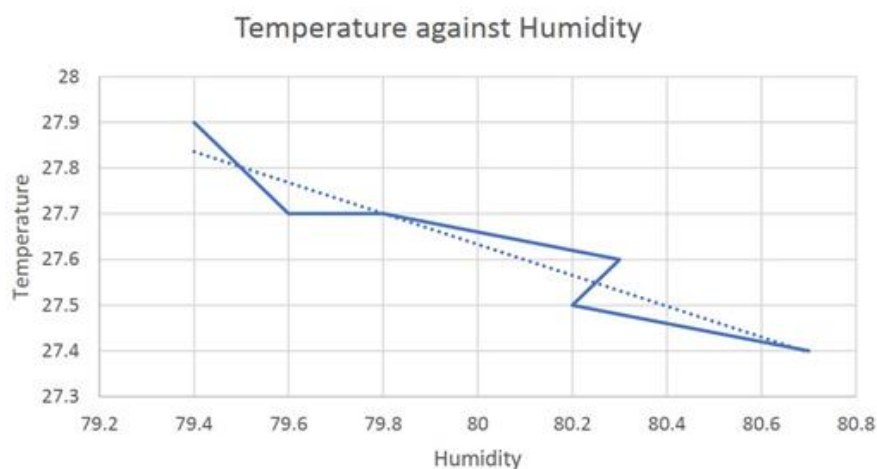


Figure 4. Graph of Temperature versus Humidity

As shown in Figure 4, the temperature decreases because the present of air which contain the molecule of Hydrogen bring the agent of water. This result shows the sensitivity of the sensor to the

growing stage. Since that the board only need 5V power supply, The LED already setup by external battery which could supply 12V. The NPN type TIP120 has been used. In order to control the volt.

3.4. VNC (Virtual Network Computing) connection

The VNC plays an important role in the development of Smart Incubator System Grow for Plant as a medium of connection between Arduino and Raspberry Pi. Therefore, inside the VNC has the capability to install any software and language inside the terminal Raspberry Pi. The Raspberry Pi run Operating System Noob as the Operating System. Beside that the Node-RED programming is deployed in Raspberry Pi in order to make the raspberry Pi as a server.

4. Conclusion

As conclusion, this system has been successfully developed with a good prototype which meet all the system parameters and objectives. This project are successfully developed which this project capable to monitor the temperature, humidity and pH in smart incubator grow system for plants. At the same time, this project gives an opportunity to control the incubator of plant grow system via distance mobile device.

Acknowledgments

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