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SURIGAO STATE COLLEGE OF TECHNOLOGY

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Bachelor of Science in Electrical Engineering

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AUTOMATED SOLAR POWERED CHAMBER WITH IMAGE PROCESSING DETECTION USING AI IN CACAO BEANS

Catherine A. Balaez, Johanni O. Dotarot, Noel P. Galolo, Norman II G. Limosnero, Arvien M. Vidal, Engr. Vrian Jay V. Ylaya

Surigao State College of Technology, Surigao City, Philippines
cbalaez@ssct.edu.ph, jdotarot@ssct.edu.ph, avidal@ssct.edu.ph, ngalolo@ssct.edu.ph, nlimosnero@ssct.edu.ph, vylaya@ssct.edu.ph

Abstract: This paper presents the design and development of an automatic solar powered chamber with image processing using AI in cocoa beans. The drying mechanism was based on the combination of direct radiation and convective heating with the incorporation of electric backup heaters to address the intermittent effect of drying. Arduino Uno and the raspberry pi 3b+ along with the appropriate sensors are used to monitor and control the moisture content, speed of the motor and temperature of the heating chamber. Direct radiation maximized the solar reception during daytime by providing sufficient heat inside the chamber. The electric heaters also provide reliable heat sources during night time, preventing the occurrence of moisture re-absorption by the beans. The developed system maintained a drying temperature 40-50°C by automatically switching the drying modes depending on the weather conditions. The prototype of the system is developed and powered using solar photovoltaic energy generated from 70- and 100-watts solar panels in conjunction with converter and charge controller. This study demonstrated a methodology for textural feature analysis on digital images of cocoa beans. Our results showed that using GLCM with RGB segmentation for image processing can contribute more reliable results. Our method was implemented through on –site preprocessing within a low- performance computational device. It is also helped to foster the use of modern Internet of Things (IoT) technologies among farmers and to increase the security of the food supply chain as a whole.

Keywords Image Processing, Mobile Application, Artificial Intelligence, Drying chamber, Raspberry Pi,

1. Introduction

Fermentation process is an important indicator of cocoa beans quality. Human workers currently employ the traditional drying method, which requires a significant amount of time and efforts. Advanced agricultural development and procedural operations differ significantly from those of several decades earlier, principally because of technological developments, including sensors, devices, appliances, and information technology.

Cacao seeds are the seed of Theobroma cacao (Sterculiacaea family), a tropical tree which is grown mostly in the wet tropical forest climate countries. It is a Philippines cash crop that has economic potentials for rural farmers but is otherwise beset with drying problems (Burguillos, Elauria, & De Vera, 2017) [1].Traditionally, drying is usually carried out using natural sun drying. The various drawbacks to this method include unpredictable weather patterns, labor intensive and prolonged rate and product spoilage(Hii, Law, & Suzannah, 2012) [2].

Drying is the most important process to preserve grains, crops and foods of all varieties. The removal of moisture prevents the growth and reproduction of microorganisms causing decay and minimizes many of the moisture-mediated deterioration reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage and transportation costs and enables storability of the product under ambient temperatures.

Thermodynamic relations should be considered in designing a solar dryer system for a specific product such as cocoa beans. Previous works includes Burguillos et al. (2017) which adopts a structural arrangement for the direct type, and the heating mode for the indirect type of drying fermented cacao beans. The dryer consists of an integrated drying chamber and convective heating with the incorporation of electric backup heaters to address the intermittent effect of drying, DC fans in parallel to enhance moisture removal and used antenna for mobility. Fermentation and drying are two main steps in the postharvest processing of cocoa beans. These steps play an important role in the formation of flavor and taste. These steps should be treated properly in order to improve the status of cocoa beans [3].

Information technology has indeed shifted very significantly in human life. It is undeniable that technology currently represents an essential role in the development process from time to time. We are entering the Industrial Revolution Era 4.0, where Internet of Things (IoT) technologies are very influential in everyday life. Even in the area of agriculture, such technologies [4,5] have many important roles. Feature extraction is an artificial intelligence (AI) method that selects or consolidates numerous variables as a feature, which can effectively decrease the substance of data processed while still representing the fundamental dataset.

The objective of the study is to design and develop an automated solar dryer system capable of monitoring and detecting moisture during fermentation using AI camera; programmed in raspberry pi 3b+. To reduce the moisture content of cocoa beans in less than 10% using Arduino Uno and its components relayed. Lastly to give secondary back-up power using solar power system and aims to implement a prototype for testing and evaluation. However, drying method can improve the quality of dried beans. Many researchers have reported study on the effects of drying method to the cocoa beans quality (Jinap, Thien, & Yap, 1994) [6].

Agriculture allowed people to create civilizations, fight hunger and work to combat challenges in population growth and climate change. This is why researchers are interested in developing and revising this technology to give more advantages to the community Galiche et al. (2011) [7], conducted a study on this system with analog-digital combination control method and the feasibility of its usage in solar dryers.

Related Literature

Solar radiation is an integral part of different renewable_energy_resources. It is the main and continuous input variable from practically inexhaustible sun. Solar energy is expected to play a very significant role in the future especially in developing countries, but it has also potential prospects for developed countries. The material presented in this paper is chosen to provide a comprehensive account of solar energy sources and conversion methods. For this purpose, explanatory background material has been introduced with the intention that engineers and scientists can have introductory preliminaries on the subject both from application and research points of view. Applications of solar energy in terms of low and high temperature collectors are given with future research directions. Furthermore, photovoltaic devices are discussed for future electric energy generations based on solar power site-exploitation and transmission by different means over long distances such as fiber-optic cables[8].

The sun has produced energy for billions of years, and it is the most important source of energy for all life forms. It is a completely renewable source of energy unlike non-renewable sources such as fossil fuels. The sun provides a consistent and steady source of solar irradiance. Solar power technologies use the sun's energy to light homes, produce hot water, heat homes, and produce electricity.

In the Philippines, the potential is even greater than the inspirational target of 1,528MW attributed to solar in the National Renewable Energy Plan until 2023. According to the DOE's 2009-2030 Power Development Plan (PDP), the country's energy consumption is seen reaching 124,067 gigawatts-hours (GWh) by 2023, from an estimated demand of 86,809 GWh by 2018 and actual demand of 55, 417 GWh in 2008. The yearly monthly daily average irradiance yield received in the horizontal plane of Surigao city is about 7.5 kW h/m2 / day with the Latitude: +9.8 (9°48'00" N) and Longitude: +125.4(125°28'12" E).

Many innovative systems have been developed that replace the traditional gravel-filled bed. When evaluating the type of system to install, consideration should be given to such factors as the type of cacao beans, space requirements, drying time, support system, and economics. These systems can be set up in either a direct and indirect place. As cacao beans production is often limited by environmental factors, interest in alternative drying practices is increasing. In this regard, automated solar powered chamber serves as a promising dryer practice that offers a solution for some serious challenges of cacao beans production such as lack of space to dry on, climate change, deforestation, rising fossil fuel prices and ecosystem degradation.

The utilization of technology is necessary to increase agricultural production [9] especially in terms of quality and competitiveness. The availability of technological innovations such as machine learning and deep learning. [10,11] is also one of the keys to improving farmer welfare and attracting the younger generation's interest in creating various derivative business opportunities.

Therefore, this work aims to use computer vision as a fast and accurate method to classify cocoa beans of fermentation, using features extracted from cocoa bean images as predictors. The proposed approach could substitute the cut-test, [illegible] to evaluate [illegible]

The uniqueness of this project is that it has a switched mode that can be used manually or automatically depending on the decision of the user. It also has a password that only authorized personnel can operate or access the system. The purpose of the AI camera is to monitor the cacao beans even if the host is not around. Using this method, it helps the farmers to improve the quality of life and less hassle. The database that is contained in computer which is then accessed by the website via the web server to display the data to determine the quality of dried cacao beans as well as the temperature, and humidity inside the chamber.

1.2 Theoretical Framework

Cocoa bean fermentation is still a spontaneous curing process to facilitate drying of nongerminating cocoa beans by pulp removal as well as to stimulate color and flavor development of fermented dry cocoa beans. As it is carried out on farm, cocoa bean fermentation is subjected to various agricultural and operational practices and hence fermented dry cocoa beans of variable quality are obtained. An automated solar powered chamber system will help the cacao beans to dry both indoors and outdoors. As a result, famers don't need to waste large amount of time to manually operate the traditional gravel-filled bed method. Instead, the farmers could monitor the fermenting process through the application being provided.

The Internet of things (IoT) describes the network of physical objects that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the Internet.[13]

Sensors are used in everyday objects such as touch-sensitive elevator buttons and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micromachinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure, or flow measurement.[14]

There are numerous IoT applications in farming such as collecting data on temperature, rainfall, humidity, and wind speed.[15] This data can be used to automate drying techniques, make informed decisions to improve quality and quantity, minimize risk and waste, and reduce the effort required to manage drying.[13] For example, farmers can now monitor moisture from afar and even apply IoT-acquired data to precision ferment programs.

The Raspberry Pi is a low-cost, credit-card-sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing and to learn how to program in languages. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

1.3 Conceptual Framework

The following figure shows the input-process-output diagram of the project.

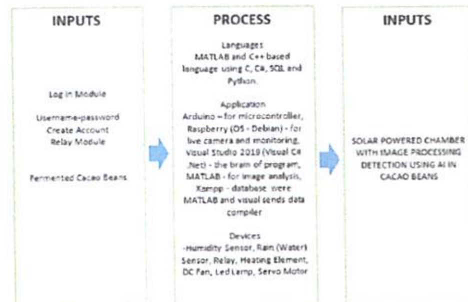


Figure 1. Input- Process- Output diagram of the project

The block diagram illustrates the general concept and explains the flow of the system. The input block is the materials needed to implement a power supply project. Monitoring systems are designed using sensors such Humidity Sensor, Rain (Water) Sensor, Relay, Heating Element, DC Fan, Led Lamp, Servo Motor. The process block contains various stages: online research, analysis, system design, implementation, construction, testing, and system evaluation. Online research methods (ORMs) are ways in which researchers can collect data via the internet. An analysis is a detailed examination of the elements or structure of something. System Design System design is the process of defining the components, modules, interfaces, and data for a system to satisfy specified requirements. Implementation is the carrying out, execution, or practice of a plan, a method, or any design, idea, model, specification, standard, or policy for doing something. Construction and Testing is the testing of materials used to build new projects, add to existing projects, or amend existing construction projects. Evaluation Assesses the quality and success of a project in reaching stated goals. Presents the information collected for project activities and outcomes.

The input and process will produce an output of the project, the innovative Solar Powered Chamber with Image Processing Detection Using AI in Cacao Beans.

1.4 Objectives

This project aims to design and implement an automated solar powered chamber with Image processing detection using AI in cacao beans using raspberry pi, Arduino uno and sensors to keep human intervention at a minimum and help local farmers eliminate the inconvenience and time-consuming traditional method of farming.

1. To foster the use of modern Internet of Things (IoT) technologies among farmers and to increase the security of the food supply chain as a whole.

2. To design and develop a solar dryer system capable of detecting moisture during fermentation using AI image processing.

3. To increase agricultural production especially in terms of quality and competitiveness. To increase agricultural production especially in terms of quality and competitiveness.

4. To improve farmer's welfare and attracting the younger generation's interest in creating various derivative business opportunities.

5. To implement a prototype for testing and evaluation.

2. Methods

2.1 Research Design

A lot of research on farming and hydroponics was required to complete this investigation. The first goal was to determine what a hydroponic system is. Hydroponics, by definition, is a method of growing plants in a water-based, nutrient-rich solution. Hydroponics does not use soil, instead, the root system is supported using water. The next goal was to determine what type of water would be compared and estimate the amount needed.

2.2 Project Design

The figure below shows the block diagram of the project

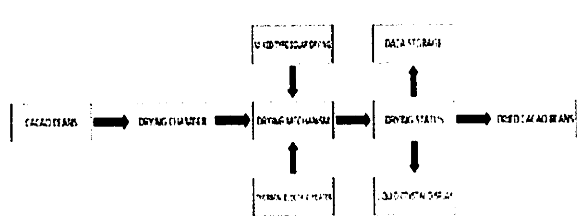


Figure 2. Block Diagram of the project

The diagram of the project shows three boxes, the first box represents the hydroponic system together with the sensors attached on raspberry pi which is the brain of the system. Sensors are connected to Raspberry Pi, temperature and humidity sensor together with the ultrasonic sensor connected to ADC (Analog to Digital). Then the sensor data will be inputted into the Database and display the output data on the webpage and then monitored through the webpage back to the database and to the hydroponic system in which the sensors are placed. The data on the webpage will be the final output, where the sensor data are displayed and can be controlled even if the user is far away.

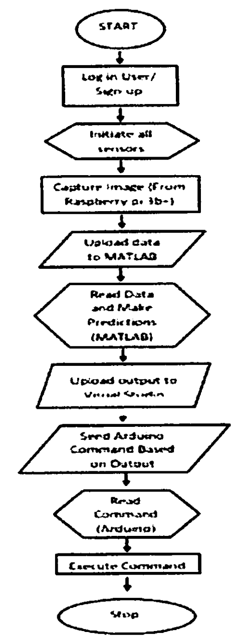


Figure 3. Flowchart of the system

The flowchart of the project is shown in Figure 3, which the researchers used as the basis on how the data collecting procedure is done. As shown in the figure, the project starts with log in users or signing up and then all the sensors initializing and then capture image from raspberry pi 3b+ by uploading the data to MATLAB, it will now read the data and make predictions after making predictions the output will proceed to visual studio and then the Arduino will send a command based on the output. The output will be read by the Arduino's command and finally will execute the command which ends the process.

2.3 Project Development

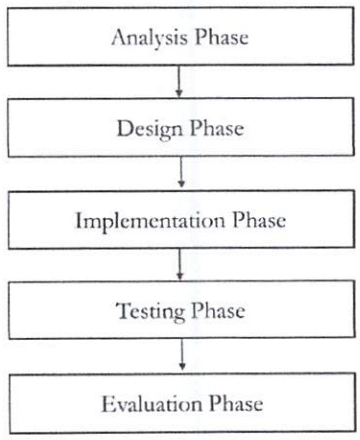


Figure 4. Project Management Diagram

The first stage in doing a project study is online research on the internet. In this generation, almost everything that a person wants or needs to is already on the internet. In this stage, the researcher will be able to gain some knowledge and ideas which could help them implement a good project.

The next step in developing this project study is system designing. Designing a system is a hard task because everything should be considered, the materials, finances, sizes, mechanism of the project, packaging, etc. Everything should be well planned so that there will be fewer problems on the next level of the implementation. Additional to that is programming, it creates instructions that tell a computer how to perform a task and how the project works.

The third step is the purchase of materials. All materials should be ordered or be ready as soon as possible for the construction of the project.

The fourth step is construction and testing. After completing the needed materials, the researcher can now start the implementation of the project. The first to be realized will be the internal parts, which are the frame of the chamber, to be followed by the construction of lower and upper part of the chamber that has 1x2 and 1x1, then Plain zin that encloses the outside of the chamber. We also added a tray where the cacao beans are placed. We used plastic as a cover so that the sunlight passes through the chamber in order to dry the cocoa beans. Trial and error are also needed to test if the project is working correctly or not.

Then finally, the packaging of the project should be neat and presentable. The last stage in this research project is system evaluation. The project will be evaluated according to its performance, serviceability, aesthetics, and features. The researcher will conduct a survey to be undertaken using paper-based techniques through questionnaires and personal interviews to hear the opinions of the participants.

2.4 Project Implementation

The project will be implemented at a place where it can be tested and performed. Researchers conduct a test and survey together with the participants, the farmers, and professionals. The researchers and the participants will manage and monitored the project if it can meet the process expectation and the said output to the project. Professionals and farmers will test the project if it is applicable to use solar drying systems with the Internet of Things (IoT). If the project will be failed to deliver the resulting output, the researchers will fix the problem and re-tested it again. Until it meets the expectations output.

2.5 Project Settings

Figure 5. Location of the place

The Automated solar drying system can be placed anywhere, either indoor or outdoor. The said project will be placed and tested in Brgy. Roxas, Mainit Surigao del Norte Professionals/farmers are invited to participate, observe and give feedback to the project about automated solar powered chamber with image processing detection using AI in cocoa beans. Researchers chose this location because it's easier to conduct a survey.

2.6 Participants of the Study

The participants of this project study are mainly the project beneficiaries, who include the farmers and professionals. The proficient evaluators are chosen to concur to their mastery that would offer assistance to confirm whether the framework's execution is palatable sufficient for the proper implementation. In contrast, the user/evaluators/ ranchers are chosen to assess whether the framework is worthy enough to utilize the said venture.

Table 1. Participants of the Study

PARTICIPANTS	f(n=10)	%
Professionals	4	40%
Farmer	5	50%
Agricultural Engineer	1	10%
TOTAL	10	100%

2.7 Instruments

In this study, the following instrument for the fulfillment of the study:

Proteus Simulator - The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. Electronic design engineers and technicians use the software to create schematics and electronic prints for manufacturing printed circuits.

DHT11 Temperature and Humidity Sensor

It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and outputs a digital signal on the data pin.

Raspberry Pi 3 Model B Plus

The latest product in Raspberry Pi 3 range, boasting a 64-bit quad-core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE (Bluetooth Low Energy), faster Ethernet, and PoE capability via a separate PoE (Power over Ethernet) HAT (Hardware Attached on Top).

Water Sensor

It detects the presence of water and when placed in locations where water should not be present, a leak.

Led Lamp

Led Lamp or Led light bulb is an electric light that produces light using light-emitting diodes (LEDs).

Stepper Motor

A stepper motor is an electromechanical device it converts electrical power into mechanical power.

5V Single Relay

This is a single channel Relay Module; relays are used to control or switch devices that use higher power than what most micro-controllers such as an Arduino or Raspberry Pi can handle. This particular relay module can control typical household appliances up to 15A.

DC Fan/ Heating Element

The direct current fans, or DC fans, are powered with a potential of fixed value such as the voltage of a battery we used 12V in DC fan.

LCD

Used to display data in devices such as calculators, microwave ovens, and many other electronic devices.

Breadboard

A construction base for prototyping electronics.

Jumper Wire

Are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering.

Power Inverter

A power inverter, or invertor is a power electronic device or circuitry that changes direct current (DC) to Alternating Current (AC).

Charge Controller

The charge controller regulates the amperage and voltages that is delivered to the loads and any access power is delivered to the battery system so the batteries maintain their state of charge without getting overcharged.

Software specification

- Visual Studio Code
- SQLite
- Putty
- Raspbian
- C++
- C
- C#

In-depth Interviewing.

It is a qualitative interviewing technique that involves conducting individual interviews with a small number of respondents to explore their perspective on a particular idea, program, or situation

2.8 Research Ethics

In this study, the researcher makes sure not to violate any legal and environmental issues. The participants of this study will be voluntary, so they will have the right to withdraw from it at any point and for any reason. Next to this, participants were fully informed regarding the objectives of the study. Participant's safety was also secured; they were not harmed or abused, both physically and psychologically, during the conduction of the study. In contrast, the researcher attempted to create and maintain an atmosphere of comfort.

2.9 Data Collection Procedure

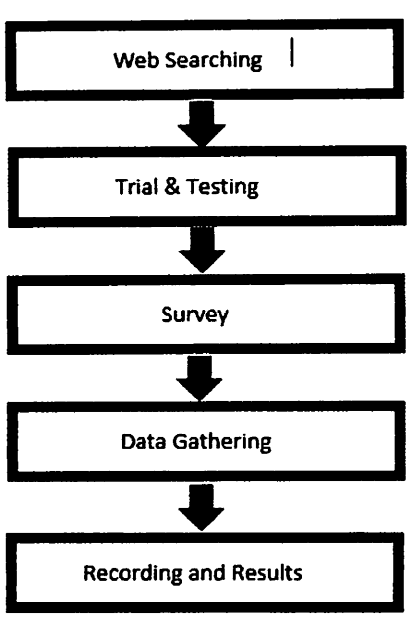


Figure 6. Data Collection Procedure Diagram

The diagram above shows the data collection procedure in doing this research project. These include web searching, trial & error testing, surveys/interviews, data gathering, and recording and results.

The first stage is web searching wherein the researcher collects some information that could help them understand further about the project and how to make it work.

Researchers focused on the issues and problems that are related to the study of interest in order to avoid errors in the implementation of the project. Conclusions and recommendations were also being noted.

Through a survey, researchers can collect information from a sample of individuals through their responses to questions.

Researchers gathered observations or measurements through survey and online searching

Series of trials and tests were conducted. The researchers gather data about the effectiveness of the project by conducting a survey, personal interviews, and providing some questionnaires to the participants. All of the data collected from survey questions and personal interviews were also recorded.

2.10 Statistical Tool

The project studies use means statistical tool. Frequency statistics simply count the number of times that each variable occurs, such as the number of males and females within the sample. Measures of central tendency give one number that represents the entire set of scores, such as the mean.

On the other hand, "Mean" Mean implies average and it is the sum of a set of data divided by the amount of data. Mean can prove to be an effective tool when comparing different sets of data.

2.11 Financial Analysis

Table 2. Materials Cost Analysis

PARTICULARS	QTY.	UNIT COST	AMOUNT
Electrical Heating System	1 set	₱1,348	₱1,348
Electronic components	1 set.	₱8,419.50	₱8,419.50
Solar power system	1 set	₱ 14,000	₱14,000
Construction Materials	1 set	₱3,225	₱3,225
TOTAL			₱26,992.5

Table 2 shows the Material cost analysis, which indicates the cost of each component that is used in the project. The packaging of the system is not included because it is free of charge.

Table 3. Fixed Cost Analysis

PARTICULAR	QTY.	UNIT COST	AMOUNT
MATLAB	1	₱10,000	₱10,000
TOTAL		**₱10,000**	**₱10,000**

Table 3 shows the Fixed Cost Analysis of the project, and these are acquired to Automated solar powered chamber System with AI image processing.

Table 4. Total Fixed Cost Analysis

DESCRIPTION	QTY.	AMOUNT
Material Cost	All	₱ 26,992.5
Fixed Cost	All	₱10,000
OVERALL TOTAL		**₱36,992.5**

Table 4 shows the overall total of the materials and the services of the project.

Selling Price:

Price = Variable Cost + Mark- up (35%)
Price= 26,992.5+ 26,992.5 (35%)
Price= ₱ 36,439.89≈ **₱36, 500.00**

The "Automated Solar Powered Chamber with Image Processing Detection Using AI in Cocoa Bans" selling price is based on the total price of the materials being used plus the product of markup and 35% of the materials used. The fixed cost of the project is not included on the price basis.

Return of Investment:

Total fixed cost= **₱10, 000**
Tax (12%) = ₱1,200.00

$$\text{ROI} = \frac{\text{Net Profit}}{\text{Total Investment}} * 100$$

= (₱1,200 / ₱36,992.5) * 100
= **3.3% ≈ 3%**

Break-Even Analysis:

Researchers used break-even analysis to determine the number of units or dollars of revenue needed to cover total costs.

Total fixed cost= ₱36,992.5
Variable Cost= ₱26,992.5
Selling price= ₱36,500

$$\text{BEA} = \frac{\text{Total Fixed Cost}}{\text{Selling Price} - \text{Variable cost}}$$

$$\text{BEA} = \frac{₱36{,}992.5}{₱36{,}500 - ₱26{,}992.5}$$

BEA= 3.89 % ≈ 4 units per month

Monthly Sales = No. Units sold pre month x selling price

4 units x ₱36, 500.00 = ₱146,000.00

Annual Sales = ₱146,000 x 12 months
= ₱1,752,000.00

The breakeven analysis of the device is the basis on how much Automated Solar Powered Chamber be sold in sales in a particular month, time, or period to realize the profit being spent. In this project, the researchers must sell at least four chamber per month to profit.

3. RESULTS AND DISCUSSIONS

3.1 Technical Materials of the System

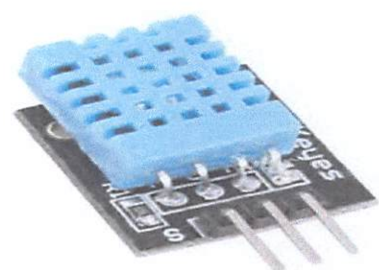


Figure 7. DHT11 Temperature and Humidity Sensor

It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin.

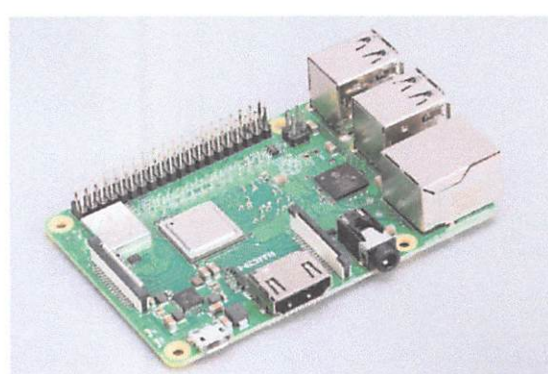


Figure 8. Raspberry Pi 3 B+

The Raspberry Pi is a series of single-board computers. They are low-cost, high-performance, and the size of a credit card.

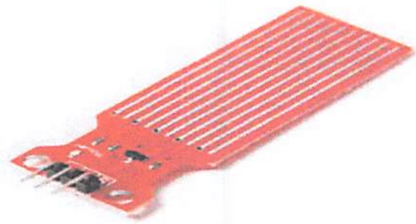


Figure 9. Water Sensor

It detects the presence of water and when placed in locations where water should not be present, a leak.

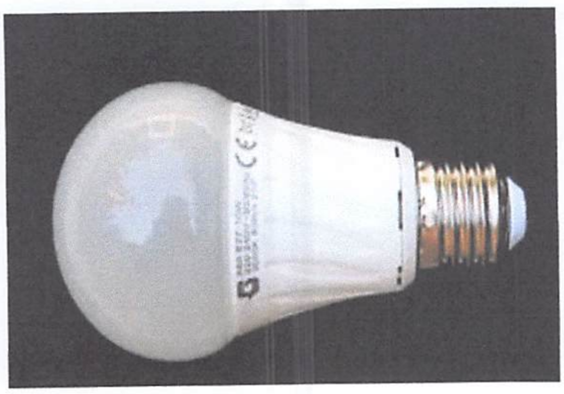


Figure 10. LED Lamp

Led Lamp or Led light bulb is an electric light that produces light using light-emitting diodes (LEDs).

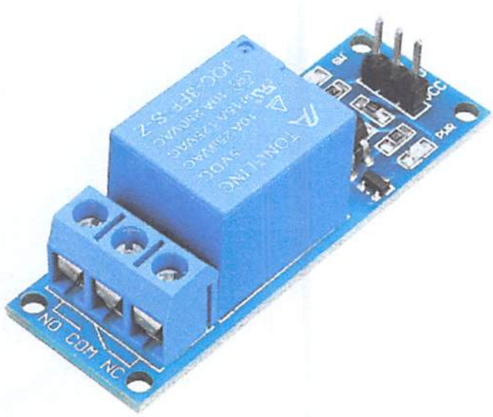


Figure 12. 5V Single Relay

It comprises components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active or not.

Figure 13. Automated solar powered chamber

The chamber where the cocoa beans being fermented.

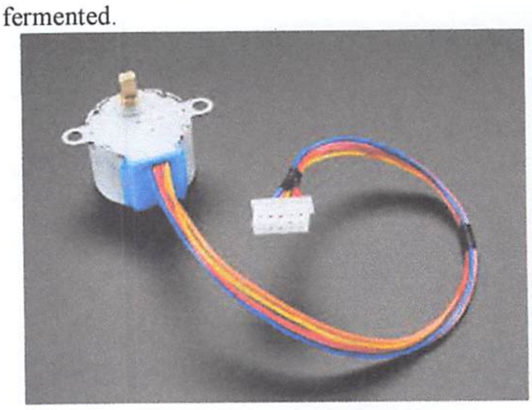


Figure 14. Stepper Motor

A stepper motor is an electromechanical device it converts electrical power into mechanical power.

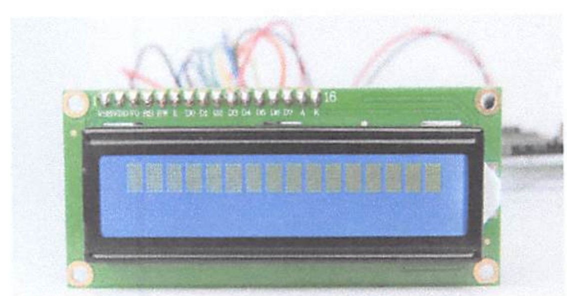


Figure 15. LCD

Used to display data in many other electronic devices.

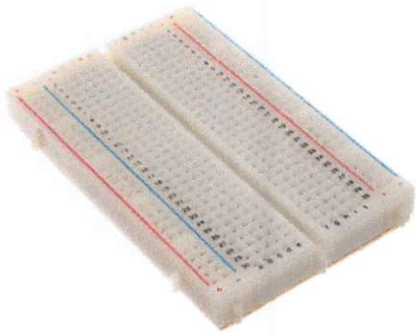


Figure 16. Breadboard

A construction base for prototyping electronics.

Figure 17. Jumper Wire

A smaller and more bendable corrugated cable is used to connect antennas and other components to network cabling.

Figure 18. Power Inverter

A power inverter, or invertor is a power electronic device or circuitry that changes direct current (DC) to Alternating Current (AC).

Figure 19. Charge Controller

The charge controller regulates the amperage and voltages that is delivered to the loads and any access power is delivered to the battery system so the batteries maintain their state of charge without getting overcharged.

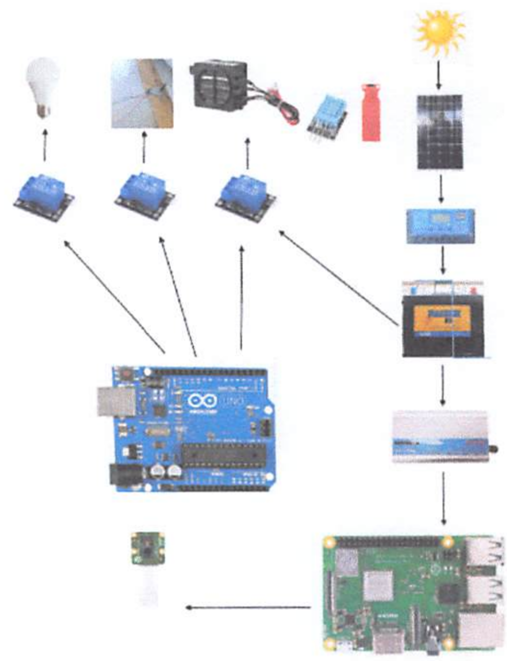


Figure 20. Architectural Design of the System

Figure shows the architectural design of the system. The arrows pointing to/from the components indicate whether they are inputs or outputs. The solar panel collects solar energy from the sun and converts it into an electrical power source stored in the battery. The solar charger controller charges the battery simultaneously stores energy and supply power to the system (inverter).

The Inverter USB (Universal Serial Bus) in 5Vdc 1 ampere, supplies the Arduino Uno, then all of its data signals of in specific relay module for e.g., LED lamp (pin 7), Servo motor (pin 8, pin 9, pin 10, pin 11), Main Source (pin 5), Heater Fan (pin 6) are connected to the Arduino Uno. Also, the passive sensors; Water Sensor (pin 3) and Humidity Sensor/Temperature (pin 2) sensor. The temperature sensor measures the temperature inside the chamber while the water sensor detects the water droplets from the rain. Arduino Uno microcontroller to command the Arduino to execute all of its commands.

The 5Vdc was supplied to the raspberry power port, and the camera was connected in camera slot module. Raspberry pi 3b+ camera both process and provide data to the raspberry pi 3b+ microcontroller. Burguillos et al. (2017) conducted a series of drying test using moisture reduction of cacao beans.

While operating in the drying mode, the data from the raspberry pi 3b+ camera and temperature sensor are encoded in the SD card every hour interval. It is also displayed in the LCD. Heating stops when too much heat output came out from the heater fan and when the temperature is below 35 degrees C the heater fan will automatically start.

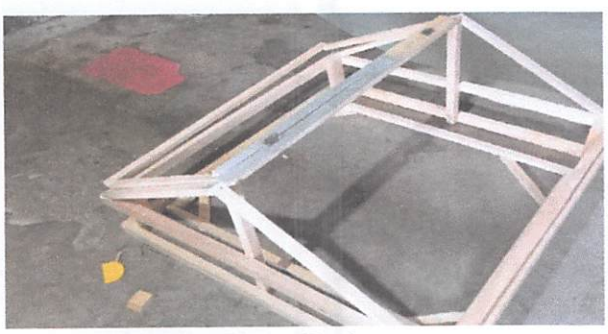
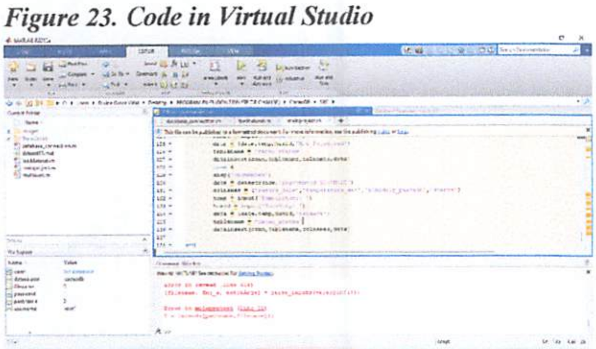


Figure 21. Frame Design

Shows the shows the frame design of the chamber.

Figure 23. Code in Virtual Studio



3.2 Evaluation Results

Table 5. Temperature and Humidity of the system Day 1

NO	Week 1		Week 2	
	T	H	T	H
1	29.6.C	74.3%	29.6.C	75.1%
2	28.8.C	80.3%	29.9.C	77.6%
3	29.5.C	76.1%	28.1.C	77.2%
4	29.2.C	78.9%	30.2.C	81.3%
5	29.7.C	77.8%	29.2.C	80.4%
6	28.9.C	79.7%	31.5.C	76.2%
7	29.8.C	80.3%	31.3.C	75.2%
R	**29.3.C**	**78.3%**	**29.9.C**	**77.6%**

Table 6. Temperature and Humidity of the system Day 2

NO	Week 3		Week 4	
	T	H	T	H
1	29.9.C	80.5%	31.2.C	90.1%
2	31.5.C	80.9%	30.4.C	92.3%
3	31.1.C	78.2%	28.8.C	95.6%
4	30.4.C	77.6%	29.7.C	90.8%
5	29.3.C	79.4%	30.1.C	92.1%
6	31.4.C	76.7%	31.2.C	91.8%
7	29.2.C	81.1%	31.3.C	93.6%
R	**30.4.C**	**79.2%**	**30.4.C**	**92.32%**

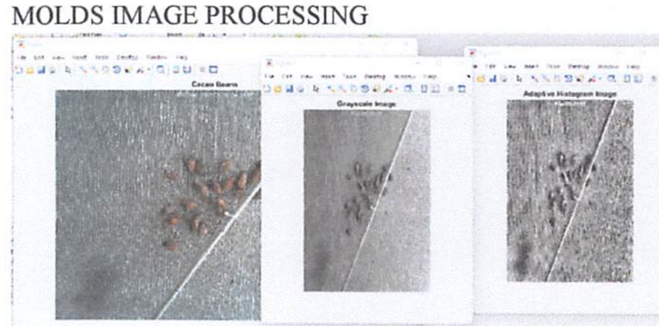
Table 7. Temperature and Humidity of the s system Day 3

NO	Week 5		Week 6	
	T	H	T	H
1	30.3.C	93.7%	29.5.C	91.6%
2	30.1.C	90.3%	30.1.C	92.3%
3	31.8.C	94.1%	31.1.C	94.7%
4	29.1.C	92.3%	31.8.C	90.1%
5	29.3.C	90.3%	30.4.C	91.5%
6	31.1.C	90.9%	29.4.C	95.5%
7	30.9.C	92.9%	29.2.C	94.7%
R	**30.2.C**	**92%**	**30.07.C**	**91.9%**

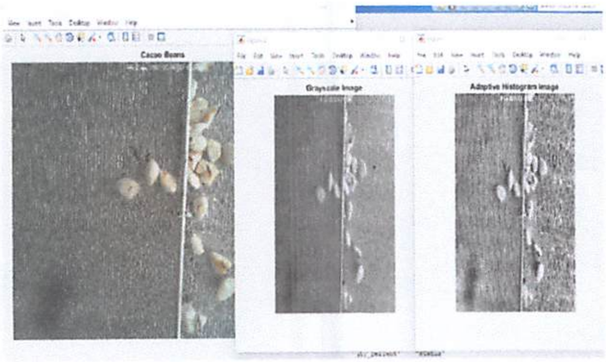
T – Temperature
H – Humidity
R – Average

Data Analysis of Cocoa Beans

MOLDS IMAGE PROCESSING



NOT FERMENTED IMAGE PROCESSING



3.3 Performance level of the design project

Table 10. Evaluation of Performance Level of the project.

TYPE

	ACTUAL				SCANNING			RESULTS
	TEMP.	HUMID.	STATE		TEMP.	HUMID.	STATE	
TEST 1	26.50	89%	WET	TEST 1	26	89%	WET	GOOD
TEST 2	26.40	78%	WET	TEST 2	28	84%	DRY	BAD
TEST 3	37	68%	DRY	TEST 3	35	63%	DRY	GOOD
TEST 4	27.4	88%	DRY	TEST 4	27	84%	DRY	GOOD
TEST 5	34	80%	FERMENTED	TEST 5	30	75%	FERMENTED	GOOD
TEST 6	36	75%	FERMENTED	TEST 6	30	76%	FERMENTED	GOOD
TEST 7	72	40%	NOT FERMENTED	TEST 7	74	32%	NOT FERMENTED	GOOD
TEST 8	36	81%	NOT FERMENTED	TEST 8	30	74	NOT FERMENTED	GOOD
TEST 9	39	42%	GOOD	TEST 9	40	38%	DRY	GOOD
TEST 10	35	46%	WET	TEST 10	32	69%	DRY	BAD

The range for the remarks of the device is Wet, Fermented, Not Fermented, and Dry.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

After making this thesis, the researchers discovered that in order to accomplish the project, each of them should participate. Because of the unavailability of materials available in local areas, the sharing of ideas is must for improvising such parts and materials that is essential for completion of the said project. This will not only provide a wide vision of innovations, but also to test the capability of a researcher on how will her/his ideas will make an impact in securing the full operation.

Aside from the researchers' contribution to one another, there are also other things the researcher had encountered; most of them are in the electrical work.

The electric backup heaters effectively maintained drying temperature from 40 degrees Celsius to 50 degrees Celsius, eliminating the occurrence of moisture re-absorption during night time. The continuous drying process effectively shorted the drying time and addressed the intermittent effect of drying cacao beans.

The Raspberry Pi is a low-cost, credit-card-sized computer that plugs into a computer monitor or TV. It is a capable little device that enables people of all ages to explore computing and to learn how to program in languages like Scratch and Python.

Recommendation

Furthermore, the researchers formulated the following recommendations:

1.
2. Add Circuits Breaker to protect the system.
3. Recommended Battery of the System must exceed 50% from the actual load of the system.
4. I recommend use only solar battery for deep cycle or slow discharge purpose.
5. Execute the proper packaging to protect the system from wet weather conditions.

5. ACKNOWLEDGEMENTS

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This accomplishment will not be possible without the people mentioned above. Thank you.

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