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"DESIGNING AND PROTOTYPING OF AN IOT-BASED CLOVES QUALITY EVALUATION AND CONTROL SYSTEM"

Dissertation Submitted in partial fulfilment of the requirements for the award of

MASTERS OF SCIENCE DEGREE IN INTERNET OF THINGS-WIRELESS INTELLIGENT SENSOR NETWORKING

Submitted by

AMOUR SALIM MOHAMMED

(REF.NO: 22102739

Decembers, 2022

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Supervised by

PROF. CELESTIN TWIZERE (*Main Supervisor);*

DR. GERARD RUSHINGABIGWI (*Co-Supervisor*)

December, 2022

DECLARATION

I Amour Salim Mohammed, Masters' student from African Center of Excellence in Internet of Things, at University of Rwanda. I declare that this research thesis is my own original work and it has never been presented before anywhere in the world.

Amour Salim Mohammed

Reg. 221027397

Signed 

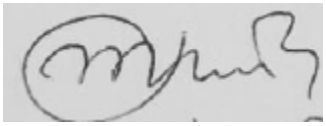
Date: 21/12/2022

BONAFIDE CERTIFICATE

This is to certify that this submitted Research Thesis work report is a record of the original work done by **Amour Salim Mohammed** (**Ref. No: 221027397**), MSc. IoT-WiseNet Student at the University of Rwanda / College of Science and Technology / African Center of Excellence in Internet of Things, the Academic year 2021/2022.

This work has been submitted under the supervision of **Prof. CELESTIN TWIZERE and Dr. GERARD RUSHINGABIGWI**

Main Supervisor *Co-Supervisor*



PROF. CELESTIN TWIZERE **DR. GERARD RUSHINGABIGWI**

The Head of Masters and Trainings ACEIoT

……..

Dr James RWIGEMA

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ABSTRACT

Cloves are the greatest valuables spices which have the common uses for food preservatives and other many therapeutics purposes like medicines, toothpaste, skin creams and soaps. Cloves originated from Indonesia and has been cultured in different part of the words, such as Zanzibar, Pakistan and so on. Cloves are sources of income, thus improving production they need best evaluation, processing and monitoring which will potentially contribute to national and international economy, therefore, to archives this it needs strong commandment on evaluation processing. The main problem faced in cloves quality evaluation to position an International standard is the lack of technology that will automatically evaluate the quality of the cloves instead of using traditionally, trial and error evaluation practices of physical touching and eye contacts. The major target of the present research is to design and develop low cost system that will automatically detect, evaluate and give out the results of the quality cloves based on different qualities, such as first, second and third qualities, aiming to catalogue valuable information of the process for cloves quality evaluation improvement. The system will determine and evaluate the color frequencies, presences of water vapour and temperature on the dried cloves by using TCE3200 and DHT22 sensors, then analyses it to provide the results superiority of the cloves. The system will use Arduino UNO microcontroller version AT mega328P in order to process input, display output via LCD and finally through GSM SIM800L module send the data to the cloud platform (ThingSpeak) for visualization and analysis. An Integrated Development Software Environment (IDE) of Arduino as an open source application will use for code generation and then upload it to the Microcontroller. The machine-learning principles thorough Fuzzy Inferences System (FIS) will use in prediction analysis for quality of cloves. It is a ruled-based expert system used to provide the output according to the inputs three sated parameters of dry cloves such as intensity as a color reading of dry cloves, temperature and moisture levels. In the end the quality will be determine based on three main samples (A, B and C), A, represent for the first quality, B for the second quality and C for the third quality. On each, a sensor is able to read five times different types quality of the cloves in order to obtain mean, standardization, regression and core relation coefficient between them. The sensors are trained to read color frequencies, temperature and moisture of dry cloves and after that, the data is drive to cloud for analytics and visualization. Due to the limitations of the ThingSpeak platform in doing data analysis and visualization, MATLAB application also used for data clearance.

Key words: *IoT, sensors, Fuzzy, Quality of Cloves, GSM module, Arduino UNO Microcontroller, Clouds and ThingSpeak.*

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LIST OF TABLES

LIST OF SYMBOL AND ABBREVIATION

LCD - Liquid Crystal Display

IDE - Integrated Development Software

GSM - Global System for Mobile Communication

FIS - Fuzzy Inferences System

ISO - International Standard Organization

LTF - Light to Frequency

GPRS - General Packet Radio Service

TCP/IP - Transfer Control Protocol/ Internet Protocol

DAQ - Data Acquisition

LED - Light Emitting Diode

PWM - Pulse Width Modulation

USB - Universal Serial Buss

ICSP - In-Circuit Serial Programming

AC - Alternating Current

DC - Direct Current

UFL - GSM Module Antenna Connector

VCC - Voltage Common Collector

GND - Ground

TXD - Transmit Data

RXD - Receive Data

RGB - Red Green Blue

OE - Output Enabler

SO - Serial Output

SI - Serial Input

VDD - Voltage Drain-Drain (Voltage Supply)

API - Application Programing Interface

HTTP - Hypertext Transfer Protocol

MQTT - Message Queuing Telemetry Transport

CHAPTER ONE

Introduction of an IoT-Based Cloves Quality Evaluation and Control System

1.1 General Introduction

Cloves are native crop in Indonesia and it they grow to all most provinces. The other nation that cultivates cloves are Mauritius and Zanzibar which becomes best producers of quality cloves [1], [2]. In addition, cloves spread to Madagascar, Sri-Lanker and Malaysia, this crop product has multiple uses such as food preservatives and other many therapeutics purposes like medicines, toothpaste, skin creams and soaps. Global cloves market Tanzania ranks third position for quality clove production followed by Madagascar taking second position led by Indonesia they holding first position with 72.9% production in 2020 [3]. The quality cloves to appropriate International market depend on whether condition, storability, harvest-ability and the drying processing [3]. Currently the main challenge and problems faces farmers in cloves quality evaluation to position an International standard is due to lack of advance technology that will automatically evaluate the quality of cloves instead of using traditionally, trial and error evaluation practices of physical touching and eye contacts [4]. The challenge and problems circumstance empower the farms to complains their issues to cloves control and quality evaluator officer of using inappropriate methods for quality evaluating process which lead to misunderstandings between them, whereas the farmers build untruth when they are given the quality results of their cloves [4]. In addition, other farmers complain that their cloves are in first quality but the results of those cloves after being passed have been brought to the others types of quality. Moreover, farmers argued about lack of proper clove control and storability which results to a switch between one famer product to another one and also they doughty about manually evaluating process its took long and consumes more time due to lack of speed up of evaluation processing. The main ideas of this work is to overcome the challenges and problems existences in cloves industries by design and develop IoT low cost system that will automatically detect, evaluate and give out the final results of the quality cloves. Such as first, second and third qualities, aiming to catalogue valuable information of the process for cloves quality evaluation improvement [4], [5]. There are different parameters specified by the International Standard Organization (ISO) that can be use in evaluating the quality of cloves to fit an International qualification, such as color of the cloves, presence of moulds and insects in the clove, extraneous matter, chemical requirements (Moisture and Temperature), packaging and storing, this project will focus with only three parameters by identify the color intensity of dry cloves, moisture and temperature [4], [5][6]. The system will use TCS3200 and

DHT22 sensors to read color frequencies, moisture and temperature presents in the dry cloves [7]. The system will use Arduino UNO microcontroller version AT mega328P in order to process input, display output via LCD and finally through GSM SIM800L module send the data to the cloud platform (ThingSpeak) for visualization and analysis. Integrated Development Software (IDE) of Arduino as an open source application will use for code generation and then upload it to the Microcontroller [8]. The system will use Fuzzy Inferences System (FIS) as a part of machine-learning principles that will use to make prediction analysis for quality of cloves based on three parameters. It is a ruled-based expert system used to provide the output according to the inputs of the system. In this work, the fuzzy inference system will be used for analysis and prediction of quality of cloves. The fuzzy logic system will identify the quality of cloves from the three input parameters of the dry cloves such as color intensity, moisture contents and temperature level [9]. The quality will be determine based on three main samples (A, B and C) A represent for the first Quality, B for the second Quality and C for the Third Quality. Each sample, a sensor will read five times different types quality of the cloves in order to obtain means, standardization, regression and core relation coefficient between them. The sensor will read color frequencies, temperature and moisture of dry cloves and after that, the data will be sent to cloud for data analytics and visualization. Due to the limitations of the ThingSpeak platform in doing data analysis and visualization a MATLAB application also used for data clearance [10].

1.2 Background and Motivation

Many locally registered cooperation practices traditionally, trial and error evaluation processing of physical touching and eye contacts, which is an outdated method. This study will focus to design and develop IoT technology for cloves evaluation that will push cloves Industries opportunity to reach International qualified standards, the evaluation system will not consume more time and will be beneficially to the cloves farms [4]. Not only that, but also the objectives of this study is to upgrade old evaluation practice to the new technology that can reduce complain between famer and local evaluator officer, whereby by using local evaluation methods gives out ambiguity quality results of cloves.

1.3 Problem Statement

Currently, many institutions involved in the cultivation of the clove crops have large gaps due to using outdated systems in the evaluation quality of the clove crops, something that leads to a big financial loss of the countries at sale or purchase assent of cloves, this is due to the use of old evaluation processing system. The system enable famers and buyers complains about the outdated evaluation processing. The currently system used to evaluate the cloves are traditionally, trial and error assessment methods by using physical touching and eye contacts which results great loss of income to the cloves producing country and make benefit to the buyers and investors of the clove crop in industrial use.

1.4 Study Objectives

Is to Design of an IoT- Based Cloves Quality Evaluation and Control System in order to simplify evaluation processing of dry cloves.

The main objective is to design and develop low cost system that will automatically detect, evaluate and give out the results of the quality cloves based on different qualities, such as first, second and third qualities.

The Specific Objectives are as follows (i). To analysing the factor that influencing the quality of cloves (ii). To design system prototype that will provide output results and send notification to the user through SMS and (iii). To enable system automatically data processing, analytics and visualization using MATLAB and ThingSpeak

1.5 Study Scope

The proposed system will use Color and DHT22 sensor to predict the quality of the cloves regarding an International standards market, the system will identify the quality of dry cloves regarding on color, moisture and temperature of the cloves. In achieving that, some parameters should be known in order to analyze cloves and provide good quality results for cloves. The parameters are as follows: -

i. The color of the cloves. International market standard determines the qualified standard of cloves it should be reddish brown to blackish brown color.
ii. The drying quality of the cloves. The cloves it should be well-dried using sun energy and at 28℃ temperature for four days.
iii. Moisture level of the cloves in container. Base on International standard quality cloves it should containing the moisture content of (<10%) in a storage area.
iv. Temperature level of the cloves in a storage room.

v. Availability of bugs and dust in the dry cloves.

vi. Rat rubbish in the cloves.

vii. Availability of stones and pieces of irons in the drying cloves.

The ides focused to design an IoT Technology that will automation cloves quality evaluation processing and provide successful output results by determine on to three parameters, colors of the cloves, moisture presences of dry cloves store in container as well as temperature level. The proposed system will use sensor technology like color and DHT22 sensors.

1.6 Significance of the Study

The study expected to contribute towards achieving the evaluation processing of the dry cloves through determination of quality of the cloves. In addition, the study will engage a cloves farm an opportunity to reach International qualified standards of their cloves.

The relevant institutions will be able to significantly reduce big losses of an income that may be incurred due to the use of proposed systems for quality evaluation of the cloves.

1.7 Organization of the Study

This chapter give an introduction of the research study and the following chapter which is chapter two will cover the related works (Literature Reviews) presented with gaps challenges followed by chapter three which describe the methodology in details. Also in this research include chapter four which consist of system model, design and prototyping models, chapter five cover the results and findings analysed from the research study carried out and the finally chapter which is chapter six describes the conclusions and recommendations of the study.

1.8 Summary

The first chapter presented the introduction of the study, from the problem statement is true that the current cloves quality evaluation processing is an outdate and error system even though still as an active and implemented in cloves industries. Through this study, I will design and develop the IoT system that will automatically evaluate the quality of cloves.

CHAPTER TWO

Literature Review

2.1 Introduction

This section describes the citations from different publication; therefore, I have been able to get a deep professional experience by going through various citations that have great content in the success of my project. In that way, I have been able to identify gaps that have high contribution to my study.

2.2 Related Works

Here are reviews the describe work that has be done by other researchers.

2.2.1 Briefly Cloves history and Uses

CROUCHER describes the history of cloves plantations on nineteenth-century Zanzibar 2007 [1]. I used CROUCHER articles as a reference to define cloves and to briefly explain the basic history of cloves crop in some countries.

According to Rehman et al in the articles of Cloves- A reviews of a Previous Species with multiple uses. The author of the article describes the different uses of cloves. Such as spices of the food as well as the Consumer products and Medicine like dental creams and spray and also describes the good quality of the cloves should contain volatile oil of (15 to 10%), also the reviews describe the alternatives drying processing it should take at least 4 to 5 days by using sun energy, the author of the publication mention that well dried cloves are heard, crisp and dark brown color with minimum of having moisture content of (<12%) which can be store for 1 or 2 years without affect the quality of it [2]. The paper not shows the technological evolves to describes the quality of cloves.

According Miraji K in the article of effect of weather in cloves production in Zanzibar – Tanzania. (2012), the paper explains the role of weather in cloves dryness processing, cloves safety, which will enable to acceptable International quality standard of the cloves, the main concern explained in the paper was to determine the maximum and minimum temperature and moisture occurrence during the cloves seasons, the high moisture of 12% level happen at the month of April due to the have rain seasons and the lowest moisture is observed during the month of February which is the month enable the cloves to dry well, also the maximum temperature of 24℃ to 29℃ its peak values during the month of February and the lowest values of temperature is observed during the month of July [3]. The paper was taken as reference to my work due to the good explanation of environmental parameters that affect the quality of cloves but there is technology involved to define the quality criterial of the quality cloves.

2.2.2 Cloves specification based on International Organization standards body.

International Standard Organization (ISO). According to International Standard Organization, ISO Draft International Standard. Second Edition of Cloves Whole and Ground Specifications. Standard describe the determination of moisture content, volatile oil content of cloves. Such as Headless cloves, Khoker cloves, Mother cloves, Clove stem and Ground (powder cloves) and also the article describes quality of the cloves should be a reddish brown to blackish brown color, should be free from living insects, moulds and dead insects as well as rodent's pollution visible to the necked eyes, should be free from extraneous matter such as duty, dust, mud, stone and pieces of wood and should be containing the moisture content of (<10%) [4].

Uganda National Bureau of Standards. According to Uganda National Bureau of Standards, Draft Uganda Standard. Second Edition of Clove Specification. The draft describes the cloves specification for East Africa Standard. Such as the quality of whole cloves should be fully grown and of reddish brown to blackish brown color, also shall have the strong perfumed spice smell and flavours, it should be free from pieces of stick or irons, molds, insects and rat trash, quality cloves should be containing the levels of moisture of (<12%) and volatile oil of less than 15% [5].

European Standard Body. According to European Standards, exporting clove to Europe, cloves Whole and Ground Specifications. The standard describes the requirements for high quality cloves should be rich in oil, whole, unbroken and without stalks as well as not contain any pieces of woody or iron. It should be reddish brown to brown in color and the head should be light brown and close. It should have the maximum moisture of less than (12%) and volatile oil minimum of (12ml/100gr). Therefore, those clove quality standards specified by standardization bodies as mention before, are due to using an old clove evaluation processing system used by local farms and evaluator officer that is an outdated system [6]. The bodies describe the criterial standard of quality cloves before the famers send it to the market. The gaps of the standard bodies are not describing evolves technology to identify the quality of cloves. Therefore, due to that challenges and gaps, I have decided to design a IoT system that can be used to make evaluation of cloves easily with a minimum time, the system will identify the quality of the dry cloves based on the color and moisture levels of the cloves by using color sensor (TCS 3200), temperature and moisture sensor (DHT22).

2.2.3 The use of color sensor in prediction of the color incidents of the objects.

Intelligent Color Sensing System for building using Arduino**.** According to Aruna et al, worked on Intelligent Color Sensing System for building using Arduino Microcontroller as a data processing and PHpOC protect as Wi-Fi module. The article describes the sensing proficiency of the building by identify types of color of building such as red, blue and green by using color sensor.

In my proposed system, Arduino microcontroller will be able to work together with GSM module for Wi-Fi communication rather than using PHpOC, because GSM module is small in size, low power consumption as well as high data rate transfer, also the modules will enable communication other components in the system and final send the data to the cloud platform for automatically make analysis and visualization of the data [7], [8]. The gaps of the paper are that, the author describes mechanism used to identify the color of the building by consider only basic color parameter that is Red, Green and Blue (RGB). Also the other gaps of the system were not able to make automatically data analytic and visualization by using cloud platform such as ThingSpeak. In my proposed work the system will automatically evaluating the quality of cloves by considering the color frequencies of the cloves, temperature and moisture levels of the cloves as input parameters. Thus, the input parameters will determine the quality of clove, the system will use color sensor (TCS3200) to detect and analyse the color frequencies of the cloves sample and DHT22 sensor to read and analyse the level of moisture and temperature of the storage area of the cloves. The system will use fuzzy logic as AI to set rules, conditions and be able to give a decision to determine the accuracy and performance of the system.

Design, Construction and Performance Test of a Color Detective Device. According to Md. Abdullah et al, worked on Design, Construction and Performance Test of a Color Detective Device, the content of the study is to detect the color of the objects by relying on the color sensor. [8]. The study works based on programmable color to frequency converter. The color sensor TCS3200 that measure the intensity of light reflected colourful object and Arduino run the logic to identify primary color, secondary color and black and white color [8]. TCS 3200 color sensor designed to detect the color of incident of the object and Arduino Nano microcontroller designed to process the color and provide the output result of the color through LCD. The sensor use arrays of photodiode, the diode consist of three filters that divided in sixteen groups of sensor. Sixteen groups have RED filter for detect the red incident, other sixteen of GREEN filter for detect the green incident and other group of sixteen BLUE filter for detection of blue incident [8]. The project used light to frequency (LTF) sensor convert light intensity to a digital form for direct interface to

microcontroller. Challenge of the paper focused on color recognition of various objects and did not use a communication protocol for data transfer, also the author describes mechanism used to identify the color of the physical object by consider primary color that is Red, Green and Blue (RGB). Gaps of the system were not able to make automatically data analytic and visualization by using cloud platform such as ThingSpeak. Thereby, in my study focused to design an IoT system to identify the color of the quality cloves and data should processed using Arduino UNO and transfer to the cloud using GSM Module for analysis and visualization. Also the system will able to automatically evaluating the quality of cloves by considering the color frequencies of the cloves, temperature and moisture levels of the cloves as input parameters. Thus, the input parameters will determine the quality of clove, the system will use color sensor (TCS3200) to detect and analyse the color frequencies of the cloves sample and DHT22 sensor to read and analyse the level of moisture and temperature of the storage area of the cloves. An at the end, system will use fuzzy logic as AI to set rules, conditions and be able to give a decision to determine the accuracy and performance of the system.

Measurement of Iodine Level in Salt using Color Sensor. According to Farniwati Fattah et al in the work of identify the level of iodine in salt, the study focused to measure the iodine levels in salt which are grouped into three categories (7-15, 20-27 and > 30) The project prototype uses the Arduino UNO and TCS3200 color sensor to detect the samples with the results of two sample that do not contain iodine and the others have different iodine level, the author use a microcontroller in measuring salt content by using salinity and conductivity sensor, but the detection of iodine in salt use spectrophotometry to measure the iodine in salt, the microcontroller function to process data received by the sensor and display to the LCD, the method used to measure the salt iodine is to read the color change of the salt, results consider that the different in color of each iodine level that is not much difference as black, light black or dark black which the condition can cause the RGB color value to be almost the same [9] [10]. The gaps of this publication is the author describes mechanism used to identify the iodine level of salt by using TCS3200 color sensor, Also the other gaps of the system were not able to make automatically data analytic and visualization by using cloud platform such as ThingSpeak. In my proposed work the system will use fuzzy logic as AI to set rules, conditions and be able to give a decision to determine the accuracy and performance of the system. The prototype was to identify the level iodine in salt and not predict the quality of salt that can be useful to human being. In my ideas is to use color and moisture sensor to identify the quality of the cloves based on color and level of moisture and temperate. The system will be design

using Arduino microcontroller and sensor will put to the cloves area, as well the data will be transferred by using GSM module technology to the cloud for data storage, analysis and data visualization.

According to Herdi Sunsanto et al in the publication of Designing of a quality Sorter Machine for Peanuts Based on Arduino. The purposes of the study are to design and manufacture of prototype unit of peanut sorting machine using Arduino Uno microcontroller to sort out the peanut quality, the difference in the color of peanuts shells is variable in determining the quality of peanuts, using the TDS230 color sensor, the skin color of peanuts that is categorize into three criterial, namely a light yellow color detect young peanut, light brown color for old peanut and if the skin has blackish color it will detect as rotten peanuts, the results show that the peanut sorting machine has been able to sort the skin color of peanuts into three types as old, young and rotten peanut [11]. Arduino Microcontroller function as control the instrumentation system, where the input signal from the sensor is controlled by the Arduino and the output signal forward to servo motor, the color sensor TSC230 used to detect the color of the skin of the peanuts and send signal to DC servo motor which is function as driver and receives motion command from the microcontroller and then direct the peanuts to the specified area [11]. Author manage to create a robotic system bus using Arduino Uno Microcontroller, Color sensor and servo motor which used to identify the quality of the peanut and enable to move the quality base on their types of peanuts to their specified position. The challenges of the system were not able to make automatically data analytic and visualization by using cloud platform such as ThingSpeak. Also the system was not able to make data communication as well as no mechanism implement to determine the working operation and accuracy of the system. In my proposed work the system will automatically evaluating the quality of cloves by considering the color frequencies of the cloves, temperature and moisture levels of the cloves as input parameters. Thus, the input parameters will determine the quality of clove, the system will use color sensor (TCS3200) to detect and analyse the color frequencies of the cloves sample and DHT22 sensor to read and analyse the level of moisture and temperature of the storage area of the cloves.

2.2.4 Drying methods to improve the quality of cloves.

According to Dewanti et al, worked on Alternative Drying Methods to Improve the Quality of Dried Cloves. The article describe oven technology use to dry cloves during the badly weathers conditions to archives the good quality of the cloves but they did not use the IoT technology in the production of quality cloves. There is not IoT technology that evaluate the quality of the cloves after drying by using oven. In this study, I develop prototype system that will use color and moisture sensor to evaluate the quality of clove after drying process [12]. In addition, the system will show data communication and visualization. Therefore, the system will enable farmers to get good sun energy at maximum of 28℃ as well as be careful on harvesting cloves at the rain season. Cloves- A reviews of a Previous Species with multiple uses. According to Rahman et al in the articles of Cloves- A reviews of a Previous Species with multiple uses. The author of the article describes the different uses of cloves. Such as spices of the food as well as the Consumer products and Medicine like dental creams and spray and also describes the good quality of the cloves should contain volatile oil of (15 to 10%) [2]. The articles also describe the bud's quality should be hard, crisps and dark brown color which having the moisture contents of (6 to 12%). Actually, the study was not describing IoT technology that can be used to identify the quality of cloves. Due to those challenges I have decided to design an IoT technology that will be automatically evaluate the quality of the cloves in a higher accurate and minimum time by using color and moisture sensor. According to Azim Ali, "Module-31: The articles describes Clove Processing and Drying. The articles describe the specification of quality clove to reach international market. Quality cloves should be well dried on the sun and should be brown in color and the drying process takes about 5 to 10 days. The moisture content of the dried cloves should be the ranges of 8% to 10%. Other matter and buds should be at 1%, the storage should be well clean, dry and cool from pests [13]. However, the study focused on describe the quality of cloves regardless the technological alternatives that can be implement to prove the quality of the cloves.

2.2.5 Maintaining the Quality of Spice Products using MATLAB and fuzzy logics

Maintaining the Quality and Aroma of Coffee with Fuzzy Logic using Coffee Roasting machine. According Harswardan et al, Indonesia coffee farms prefer to use traditionally cauldron to roast their coffee beans, which is an inefficient and resulting unequal roasted level for the coffee beans. The study propose a temperature control system based on fuzzy logic for coffee roaster machine [14]. The system controls the temperature in accordance with the demand roasting level. The thermal camera is attach inside the roasting chamber to monitor the heat on the roasted coffee

beans. The thermal camera is integrating with stirring mechanism to equalize the heat among beans. The target of this reviews in my study is to know the actually means of using fuzzy logic to predict the quality of the color by initiate the rules and principle of the fuzzy. In my work I will use fuzzy to set the rules in prediction of the quality of the cloves. The TCS3200 and DHT22 sensor will sense the data from the sources and then fuzzy rule will be apply to identify the data and make decision regarding sated rules and provide the correct output results [15].

According to Liging Zhao et al in the work of designing of peanut sorter machine detector by using Arduino Microcontroller. Use color peanut shell to determine the quality of peanuts. The ideas focused to design system that will measure the quality of peanut by using TDS230 color sensor [16] [11]. This used reference in my work because one portion of my work is to detect the level of moisture and temperature of a clove in order to determine the quality of cloves. Instead of using TDS230 color, I prefer to use TCS3200 sensor for high accuracy.

2.3 Scientific Contribution

The research work on the designing and development of a prototype of cloves Quality Evaluation and Control System that can be used to automatic evaluating the quality of cloves easily with a high accuracy and performance with limited evaluation time, the system will identify the cloves quality based on the color, temperature and presence of water vapour (Moisture) in the dry cloves. The system will use color sensor (TCS3200) and DHT22 sensor for data collection. The data will process using Arduino UNO Microcontroller and finally GSM module will transfer the data to the cloud platform (ThingSpeak) for data analytics and visualization. The proposed system will use fuzzy logic as AI to set rules, conditions and be able to give a decision to determine the accuracy and performance of the system.

2.4 Summary

After successfully reviewing various publications and journals from many scholars through their different ideas on the use of TCS3200 and DHT22 sensor, I have been able to design a system that can evaluate the quality of cloves to fit an International standard that will be able to solve the problems, challenges and complains that arise in the evaluation of quality cloves between farmers, buyers and evaluate officers.

CHAPTER THREE

Research Methodology

3.1 Introduction

Due to the challenges that exists between farmers and traders of the clove crops, it is because of the quality of the cloves themselves. Farmers say cloves are standard quality but buyers claim it not quality. In that sense, after discovering these challenges, we have come up with the idea of designing an IoT system that will solve those questions. Among the methods that have been implemented to accomplish this system is by categorizes in different parts and section. Among the methods is to briefly describe cloves processing steps, to define the research process and design, software development methods ending with briefly explanation of microcontroller and communication media that will be involves to accomplish the system.

3.2 Cloves Processing Steps

There are four important processing steps of the cloves whereas farmers should follow when the clove harvest season begins. If those steps are follow as desired, it will enable the cloves to reach the International market [13]. The steps are describing in the figure 3.1.

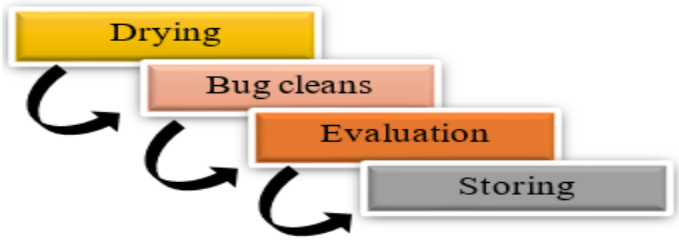


Figure 3. 1: Cloves Processing Steps

i. **Drying.** July is the start of the cloves harvest seasons and the scent of cloves is everywhere as they lie in piles in the sun. Generally dry and warm under natural process can take about four to five days and the process is done by hand, throughout Zanzibar, with daytime temperatures average is about 28° C (82 ° F). This is about the as cool as the area get throughout the year, but even so the night rarely dips below 18C (64F) regarding fresh drying cloves it should consist 8 to12 moisture contents levels [13].

ii. **Bug cleans.** After the cloves are well dried the owner of the crop sit and remove out unwanted things in the crops, such as rat droppings, pebbles, leaves, cloves hook and pieces of metal or dry sticks, this is a critical process because it maintains the International qualified market.

iii. **Evaluation.** Currently evaluation processing is done manually, officer use an outdated technology to evaluate the quality of cloves by physical touching and eyes contact and sometime smell of the cloves, evaluation processing is located in rural area where famers drying it, sack and then store them in a safe place for locally sold or external exportation. This is evaluation processing is soon done after bug cleans. Therefore, due to main evaluation challenge as mention above we introducing low cost system that will automation detect, evaluating and gives out the final results of the quality cloves based on different grades.

iv. **Storing.** It is the last step after cloves are evaluated then are well packed in special sacks or containers that are dry and stored in a room that has a good temperature and no moisture, ready for exporting to the global market.

3.3 Research Process

The designing approach it constructs the system in physical design, which reflects hardware components selection, and design, logical design that reflects software elements selection and design. Based on the waterfall model that I have been select, I decided to design the work plan in three phases. First phase is about ideas generation, describe factors analysis concerning quality cloves and prepare system proposal. The second phase was about to design system architecture, flowchart and set algorithms. The final phase was about prototyping and results analysis. The following figure describe the overview phases that will be involves in research and system development from the scratching ideas to the final output of the system [17].

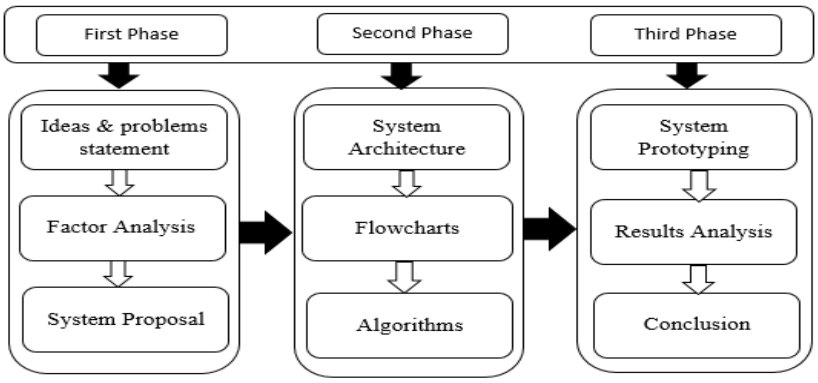


Figure 3. 2: Research Process

First Phase. This is the initial source of design of this project; it focusses is to help the issues facing farms in cloves industries. The phase is about ideas generation, describe factors analysis concerning quality cloves and prepare system proposal. The phase was dealing with ideas development and problems analysed regarding the existing evaluation system. After that I came up with design IoT system the will be automatic evaluate the quality of cloves [17].

Second Phase. The phase dealing with system architecture, flow chart development and algorithms in order to show the flow of operation of the system.

Third Phase. It is about to develop system prototype which will show the operation of the system and provide results analysis and output and ending with conclusion [17].

3.4 Research Design

To achieve the steps included on the approval proposal, a prototype will be design and implemented. The existing of locally evaluation system of clove is critical challenges and problems to the cloves farms, such as consumes more time with high numbers of evaluation error.

Therefore, to minimize the challenge we came up with design a system that will automatic evaluate the cloves. The fuzzy logic rules will be use to improve the existing algorithm to analyses the data and provide precise prediction an output. The propose solution consists of TCS 3200 color sensor used to detect the color of the dry cloves and DHT22 sensor used to measure the presences water vapors and temperature in storage places of the cloves. The data collected will be processed and analyzed in the ThingSpeak cloud server where the IoT technology incorporate with fuzzy logic system to process, analyze to provide the output results and prediction [17].

3.5 Software Development Methods

Software development process will frame the work in different steps. Through this thesis, the waterfall model it will work very well compared to other models in improving the design [18].

3.5.1 Waterfall Model

The model has been select in this thesis because it will divide the system in a sequence and linear approach. The model will be arranging in several phase and each phase should clarify the objectives of the system. Each phase will be come after phase whereby the output of one phase will the input of the following phase. Main advantage of using waterfall model because the phase cannot intersection, each phase should be complete before moving to another phases until the process is complete [19].

3.5.2 System Development Phases

Are those phase that will be implement in the development of the system. The best approach of designing is to use the waterfall model. The phases are briefly describing in the figure 3.3.

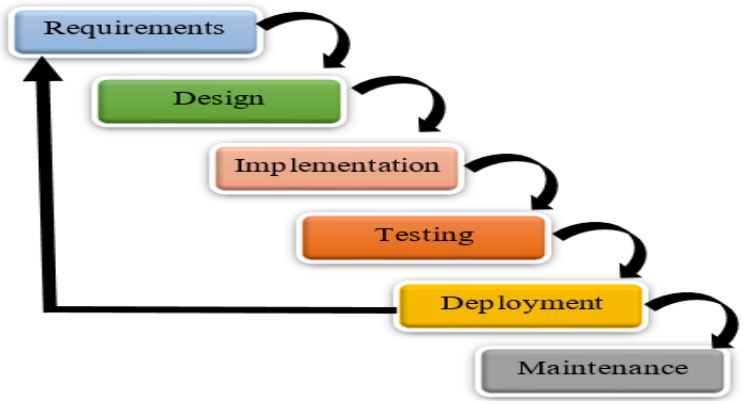


Figure 3. 3: System Development Phases

i. **Requirements Collection.** The phase describes the collection of requirements from different stakeholder of the cloves form. The requirements are gather based on the problems statement and consultation of participant of cloves farm such as famers, evaluation officers and Cloves State Corporation teams parallel with reviews other external source such as publication and research done by other researchers. Finally, the requirement was collected, organized, analyse it and select the appropriates ones based on the research objectives and were documented for implementation [19].

ii. **System Design.** It defines the great level and low-level design for the project. In the designing phase, the system will cover the organization level plan such as system architecture, block diagrams, use case diagram and prototyping of the system. The general ideas of this step is to provide clear prototypes of the system that well be easy to understand [19].

iii. **System Implementation.** The steps describe the coding processing, prototype and purifying the codes accordingly. Fuzzy logic principles and rules will be implement in this phase. General the codes will created based on fuzzy logic and then the system will display the results to the LCD and serial monitor.

iv. **Testing.** Complete system will be testing and identifies any defects in the system. Then all defects are fixed and test again to ensure the system is well operating.

v. **Deployment.** Then finally, after those step motion above the remaining phase is deployment and maintenance. Whereby installation of the system will be done.

vi. **Maintenance.** This is the finally phase of the model whereby manually of the system will documenting for future uses and maintenances operations of the system. This is to ensure that the system is running smoothly without any downtime.

3.5.3 Reason of using waterfall.

In this thesis, I prefer the use of waterfall model [20] due to the following reasons.

i. The model goes parallel with the system requirements.
ii. The definition of the proposed product was stable.
iii. No abstruse requirement for the system.
iv. Applied technology is very easy to implement and understandable.
v. The project development prototype is short and will be complete in a fixed period.

3.5.4 Merits of prefer using waterfall model.

i. Presence of clear structure based on user requirements.
ii. Smooth transfer of information. Data are record appropriately in one phase to another phase.
iii. Waterfall work for small project where requirements are clear defined and understandable.
iv. The prototypical parts are treated and complete one at a time, phase do not overlap.
v. Easy to manage due to the rigidity of the model. Each phase ha a definite deliverables and a review process [20].

3.6 Data Transmission

GSM module will receive serial data then will retransmit the data to the cloud. The module consists of different components such as voltage regulator, microcontroller, antenna, GPRS modules and SIM cardholder. I prefer using this module because will accomplish many communication services, such as make or receives phone call, internet connection through GPRS as well as TCP/IP services [21].

3.7 Arduino Serial Monitor Tools.

In achieving the project and provide an output as accepted, I will use Arduino serial monitor tool for debugging and error correction. Whereby serial monitor is a tool that connect between the computer and the Arduino platform, it enables to send and receives text messages handy for debugging and error corrections, is an essential tool when creating projects with Arduino. It can be used as a debugging, testing out concepts or to communicate directly with Arduino board [22].

3.8 Summery

In this chapter we have been able to describe the methods that have been involved in making this system successful such as the use of software models, research process and cloves processing stages.

CHAPTER FOUR

System Design

4.1 Introduction

In the proposed system we implement and connecting different element and components based on the requirements for data generation, data processing and final provide output results for visualization and analysis, the design subdivides in different unit such as physical and logical design [23].

4.2 Logical Design

This section describes the proposed system design into the proposed system technology, system architecture, applied technology, conceptual design, layered architecture, applied parameters, data generation and data flow of the proposed system.

4.2.1 System Architecture and Circuit Diagram

The figure 4.1 below describe the architecture and circuit design of the system, the study intends to develop the system that will automatically evaluate the quality of cloves. The component are installed and link each other that enable working together to archive the goals [23]. The design architecture is based on the data collection by using sensor. The Fig.4.1 describes the working operation of the system; the main parts of the design are the sensing data, communication and output results. The sensors used to collect data, then microcontroller is processing the data and finally it sends to the cloud server through communication devices GSM SIM800 for data analytics and visualization as well as send SMS notification to the users.

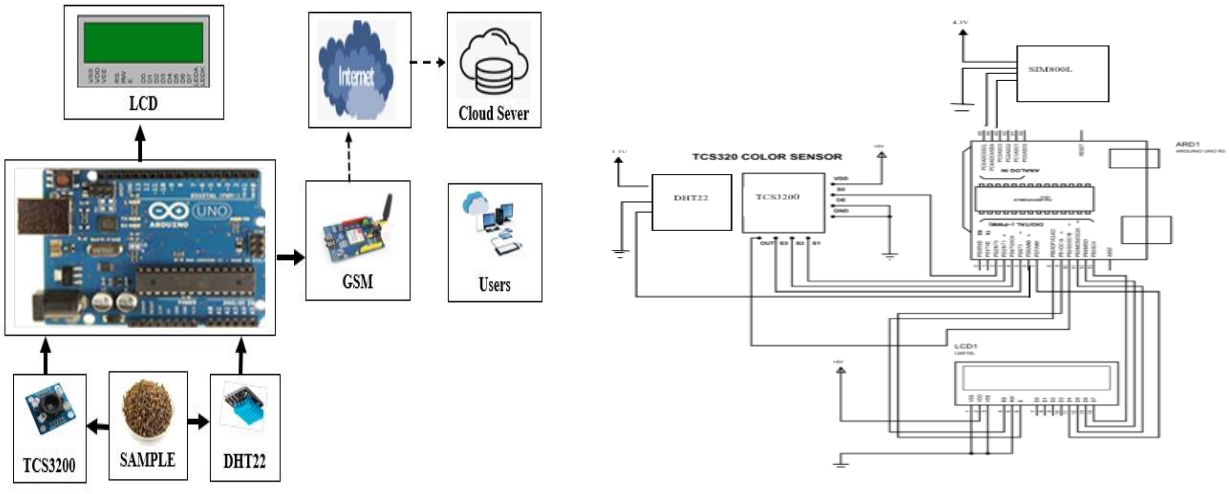


Figure 4. 1: System Architecture and Circuit Diagram

4.2.2 Applied Technology of the System

The system will apply several technologies in order to make sure the data collected from the sensor is digitizing processed and could be simple to transfer to the cloud. Among the technologies involves are as DAQ and GSM.

IoT Data acquisition technology (DAQ)

The DAQ technology has the relation between the place where data being collected by sensors, monitoring, controlling and within its platform. DAQ is the method of digitizing information by using sensors s from the physical environment that can be stored, analysed and displayed [24], [25]. The sensors can automatically adjust its data collection rate from very low frequency to high frequency to data output rate when the physical variable sensed dramatically changed by using method of self-adaptive records achievement. The technique can help to decrease power consumption, bandwidth resources and data transmission burden [25]. In this study, the TCS3200 color and DHT22 sensor used to collect data into digital ways from cloves then send to the cloud for processing, analysis, and visualization.

Data communication technology

The transmission of collected data from the sensors require communication media to reach its destination. In this study, the SIM800L GSM used as a media of communication protocol for signal data transmission from sensor devices to the cloud server. The protocol used to send signal data through cellular technology of 2/3G of mobile data services. It operates at 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands [26], [27]

4.2.3 Conceptual design

The system architecture as Fig.4.1 above has already described how data collected form sensors and sent to the cloud ThingSpeak. The data will be collected, processed and final send to the cloud for analyses and visualization. The more description on analysis and visualizing step forward to chapter five. The study used the fuzzy logic system through MATLAB for testifying the accuracy and working operation of the proposed system. The ThingSpeak cloud server also supports the data visualization dashboard and MATLAB visualization applications, which is very important in the management of data visualization reports [28]. The more details of fuzzy logic system implementation are explaining in the Software requirement selection.

4.2.4 Layered Architecture of the System

The system is composed with the three layers' architecture, physical layer whereby the sensors are install and sensing data from the cloves area., the second layers is about the networking layer or

communication layered whereby the uses of Transfer Control Protocol/Internet Protocol (TCP/IP) which will be used to support communication means of data transfer to the cloud and application layer where by the data will be storing to the cloud for the feature uses [29].

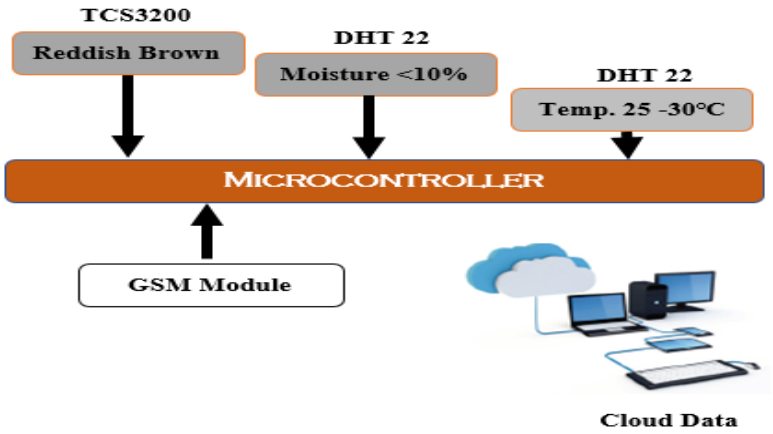


Figure 4. 2: System layered Architecture

The table 4.1 show in briefly explanation of layered Architecture of the system.

Table 4. 1: System Layered Architecture

No.	Name	Description
1	**Application Layer**	This layer is responsible to provide application specific services to cloves farmers, evaluate officer and Management Authority users as data analytics and visualization.
2	**Network Layer**	The GSM communication protocol with 3G network services used transmit data to the cloud.
3	**Perception Layer**	Perception or physical layer, where the proposed system sensors; TCS3200 color sensor and DHT22 moisture sensor are available in this layer for collecting required data of dry cloves color, temperature and presences of moisture in the dry cloves. Then the collected data then sent to the microcontroller.

4.2.5 Parameters

International market standard determines the qualified standard of cloves it should be reddish brown to blackish brown color. Moisture level of the cloves in container it should containing the moisture content of (<10%) as well as temperature level of 25℃ to 30℃ of the cloves in a storage place. Here are some parameters that will used to analysis the quality of the drying cloves. Color, moisture and temperature as reflected by International standard.

4.2.6 Data Flows of the System

The system is made up of sensing task whereby the sensor will sense and read the data from the sensor devices and then the sensing data will be calculated by evaluates the color frequency, temperature and moisture and then upload to the cloud. Then data will send to the condition, if data is well receiving, then it will be set to the conditions in order to evaluate the quality of the cloves in three quality levels and end the processing. In addition, if the data not received to the condition will be reset again to the processing [30].

// Read the current detection color, temperature, moisture and prints

BEGIN

First Condition
If color frequency is A AND Moisture level is 6 to 10%, AND Temp. Level is 23 to 26℃ THEN printout, First Quality
Second Condition
If color frequency is B AND Moisture level is 10 to 14%, AND Temp. Level is 21 to 22℃ THEN printout, Second Quality
Third Condition
If color frequency is C AND Moisture level >14%, AND Temp. Level is < 20℃ or >30℃ THEN printout, Third Quality

- ***Else***

No sample detection

END

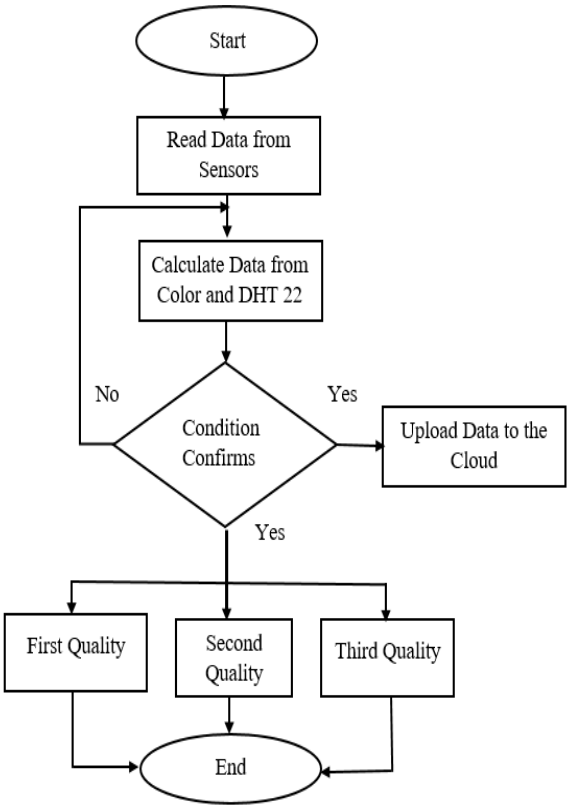


Figure 4. 3: Data Flow Diagram

4.3 Physical Design

Physical design divided into four parts; system structure, system components and communication devices, system requirements and ending with Fuzzy Inference System (FIS). Also it made of sensing capabilities which consists sensors that stimuli the physical environment like detecting color frequencies, temperature and moisture presence of the dry cloves. The system components consists of Arduino Uno Atmega328P microcontroller, GSM communication protocol, cloud platform for data analytics and the LCD for output results for user notification [31].

4.3.1 System Structure

In the proposed system, the sensors that will be able to provide the quality of the cloves will be properly placed in the area where the cloves are stored. Sensor will be work to deliver accurate data on the quality of these cloves. Even though we need to make sure, our sensors are maintaining and working properly in order to provide accurate results of the cloves. The system will divide into two main parts, which are hardware architecture and software details. In hardware architecture, the design of the circuit will be construct with different IoT devices and components. While in software development, the completely porotype will be operated via programing codes [31].

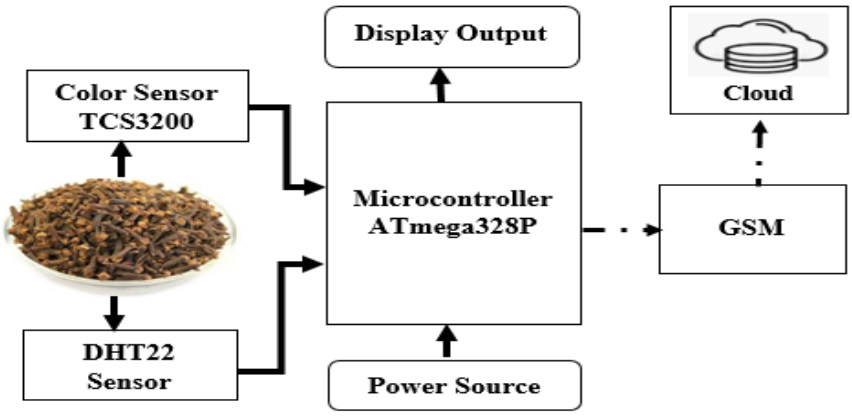


Figure 4. 4: System Structure

4.3.2 System Components and Communication Devices

These are the tools that have been used to achieve the entire exercise of this system. These tools are apply in each part of the project accordingly [32]. Among the tools are as follows.

Microcontroller (Arduino UNO).

It is a hardware developed with Integrated Development Environment (IDE) that allow open source programmable. Now a day the use of Arduino is more widely used in monitoring devices for industries, homes and others smart body controller [32]. It is a lower cost, flexible and ease to use programmable open source microcontroller body that can be integrate with different electronic projects; it will interface with other Arduino body, shield and Raspberry Pi body that can control relays, motors, output and LED. The body consist of 14 digital input and digital output pins of that 6 pins will be use as PWM output, 6 analog inputs, USB connection, power jack, ICSP header and reset button. It enables communication with the computer using USB cable or power it by using a AC to DC adapter or battery and also can receives or transmit signals when links with Arduino

shield or when links with GSM modules for data communication [32]There are different types of Arduino in the Market but Arduino UNO in the most classed widely used.

It is a lower cost, flexible and ease to in usage programmable open source Microcontroller board which can be integrated with different electronic projects, it will interface with other Arduino boards, shield and Raspberry Pi board that can control relays, motors, output and LED.

Figure 4. 5: Arduino Microcontroller

GSM SIM800L Module

It is a cellular module, which allow for GPRS broadcast, transfer and delivery SMS as well as making voice calls. The module will be connected to the microcontroller in order to receives serial data then will retransmit the data to the nearby access point as text SMS to the host server. The devices have different components such as voltage regulator, microcontroller, antenna, GPRS modules and SIM cardholder. The module accomplishes many communication services, such as make or receives phone call, internet connection through GPRS as well as TCP/IP services [33]. It uses 2A during transmission or about 216mA throughout phone calls or during network data interchanging.

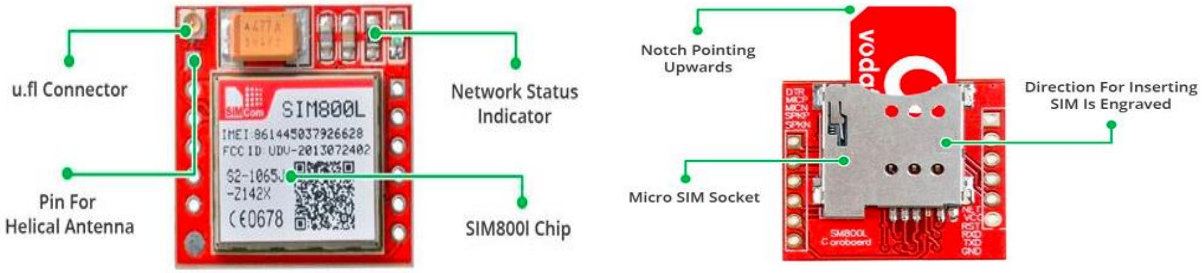


Figure 4. 6: Front and Backside of SIM800L

Table 4. 2: SIM800L Module Power Supply

Modes	Frequency	Current Consumption
Power down		60uA
Sleep mode		1mA
Standby		18mA
Call	GSM850	199mA
	EGSM900	216mA
	DCS1800	146mA
	PCS1900	131mA
GPRS		453mA
Burst		2A

There are two methods that can use to adding a probe (antenna) to the GSM module. First, one is Helical GSM antenna usually comes with module and solders directly to NET pin on SIM800L board; this is very useful for space saving in your project. The second one is any 3dBi antenna with UFL to SMA adapter and can be connected on the top-left corner of the module, this type has better performance compare to the first one [33].

SIM800L with Arduino Interface

SIM800L connected to Arduino Uno as figure 10 and table 2 below shown.

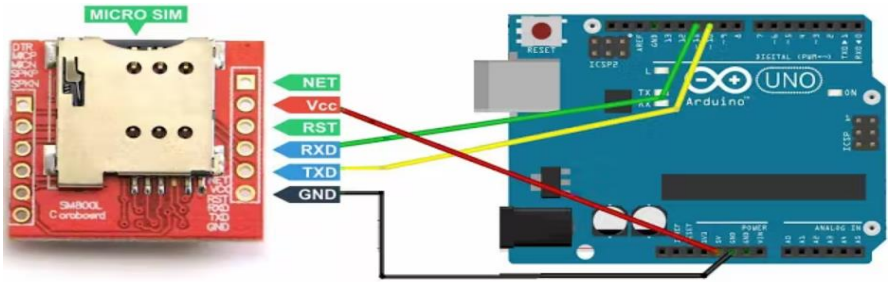


Figure 4. 7: SIM800L with Arduino Interface

Table 4. 3: SIM800L Pinout Configuration

SIM800L Pin	Arduino Uno
VCC pin	+5V
GND pin	GND
TXD pin	Digital pin
RXD pin	Digital pin

TCS3200 Color Sensor Module

It's a programmable color converter that combine configurable silicon photodiode and a only solid CMOS integrated circuit, power supply of TCS3200 color sensor is 2.7 up 5.5v [27], [34]. It

measures the color of an object and converts it into information that can be understood. The out result is a four-sided wave (50% duty cycle) with incidence straight proportional to light intensity. Digital input pins and digital output allows directly interface to a microcontroller. Output enable places the output in the high impedance state for multiple unit sharing of microcontroller input line. This is the crucial components in the projects; the main activities are to detect the color intensity of the dry cloves. In the system, the sensor will detect different intensity sample of dry cloves then will interpret base on the color types such as black, brown or gray. Color sensor measure the basic primary color such as red, green and blue by analyze the percentage of (red, green and blue) and detect the reflected light intensity of RGB color [40], but combination of the color intensity at different proportion provides other types of color (Color Calibration). TCS3200Color sensor is the one of the types of RGB color sensor, which is programed to convert colors into frequencies that are directly proportional to the intensity of light [34]. The color illuminated by led will reflect led light towards photodiode and the reflection of light has different wavelength depending on the color of the detected object. The sensor can read color modes (Red, Green and Blue) through 64 photodiodes, where each color read 16 photodiodes. Color sensor represent the detected color of the dry clove with RGB model which has values from 0 to 255, example the value of red color is 190 and 195 will be calibrate to 255 and 0 to show the closest and the farthest distance between the cloves and the sensor at the time of measurement process.

Figure 4. 8: TCS3200 Color Sensor

Working Principle of TCS3200 Color Sensor

The module has arrays of photodiodes with four different filter, a photodiode is a semiconductor device that convert light into a current, the sensor has the following photodiodes [27], [34], such as:-

- 16 Photodiodes with red filter, which is sensitive with red wavelength.
- 16 Photodiodes with filter of green color, which is sensitive with green wavelength.
- 16 Photodiodes with filter of blue color, which is sensitive with blue wavelength.
- 16 Photodiodes but no filter.

TCS3200 Converter.

The module gives the ability to make selection of photodiode filter reading, which enable to detect the intensity of the differences color. The sensor has a power flow to frequency converter which used to convert the photodiode reading into a square wave with the frequency that is proportional to the light intensity of selection color which frequency then reading by Arduino [27], [34]. As the figure 4.9 shown.

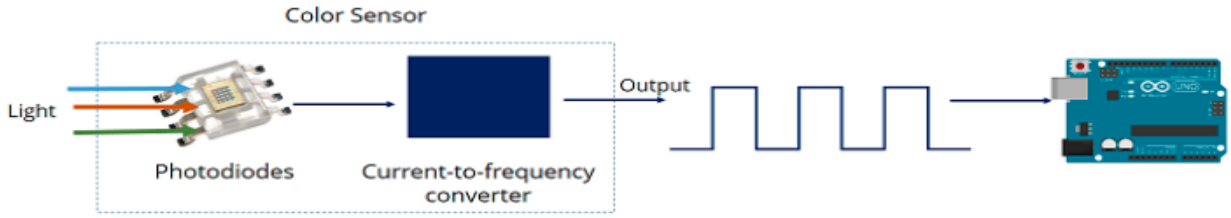


Figure 4. 9: TCS3200 Color conversions

TCS3200 Pinout Configuration

The following figure 4.10 and table 4.4 briefly describes the pinout configuration of TCS3200 Color sensor**.**

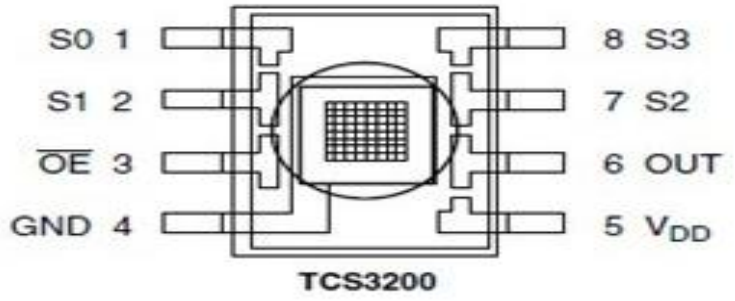


Figure 4. 10: TCS3200 Pinout Configuration

Table 4. 4: TCS3200 Pinout Configuration

Pin Name	I/O	Description
GND (4)		Power Supply Ground
OE (3)	Input	Enable for Output Frequency (Active low)
OUT (6)	Output	Output Frequency
SO, S1 (1,2)	Input	Output Frequency Scaling Selections Input
S2, S3 ()	Input	Photodiode Type Selection Input
VDD (5)		Voltage Supply

TCS3200 Filter Selection

To select the color read by photodiode, you are supposed to use the control pins S2 and S3. If the photodiode is connecting in parallel, setting the S2 and S3 LOW and HIGH in different combinations allow choosing different photodiodes as the table 4.5 shown.

Table 4. 5: TCS3200 Filter Selection

Photodiode Type	S2	S3
Red	LOW	LOW
Blue	LOW	HIGH
No filter (Clear)	HIGH	LOW
Green	HIGH	HIGH

TCS3200 with Arduino Interface

The module can be easily interface with Arduino Microcontroller, connect the OUT pins of the sensor to Arduino digital pin 8 and then connect S2, S3 to pin D7, D6 by the way connect S, S0 to pin D5, D4 and finally connect bias to the sensor Vcc to 5V and Gnd to Gnd pin. Finally upload the Arduino code for color sensor [34]. The figure 4.11 show the connection in briefly.

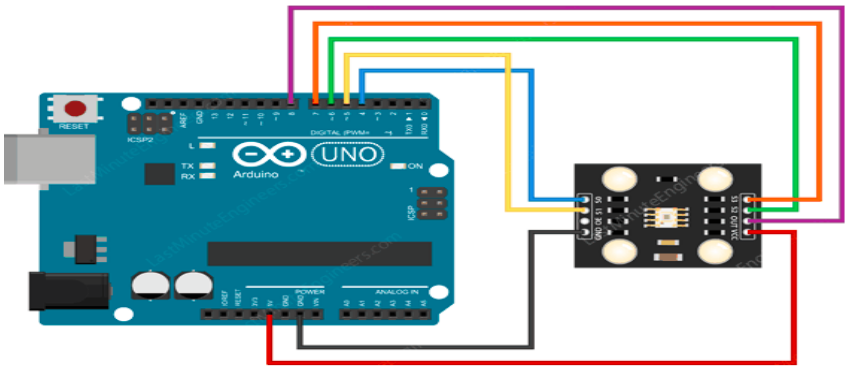


Figure 4. 11: TCS3200 with Arduino Interface

DHT22 Temperature and Humidity Sensor

It is a not expensive digital sensor for sensing temperature and presences of water, the module can be easily interface with different microcontrollers. The main activities of the sensor are to detect the moisture and temperature of surrounding environment (Store) of the dried cloves. The module it contains 8bits microcontroller internally and respond clear and fast. In this project will be able to detect and quantify the temperature of the storage place of the cloves on the ranges 0 to 50 degrees likewise the level of moisture on the range of 0 to 50 % [35].

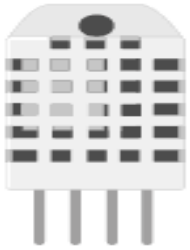


Figure 4. 12: DHT22 Sensor

Working Principle of DHT22 Sensor

The sensor module consists of capacitive humidity sensing elements and other sensing element for detecting temperature, the capacitor has two electrodes with a moisture controlling substrate as a dielectric between them. Change in the sensing values occurs when the variation in moisture levels, the integrated circuit detect and process the changing of resistance values into digital form, for measuring temperature the sensor uses negative temperature coefficient thermistor which cause a decrease in its resistance values with increase in temperature [35]. The table 4.6 shown in briefly working principle of DHT 22 sensor.

Table 4. 6: Working Principle of DHT22 Sensor

Module Operations	**Working Principles.**
Operating Voltage	3 to 5V
Max Operating current	2.5mA
Moisture Range	0 to 100% of 2 to 5%
Temperature range	-40 to 80℃/ ± o.5℃
Sampling Rate	0.5Hz (reading every 2 seconds.)
Advantage	More accurate

DHT22 Pinout Configuration

Vcc is pin one supply power to the sensor with the voltage range of 3.5v to 5.5v. The 5 meters' cable length is support for 5v and 1-meter cable can be supporter of 3.5v. Data, which is pin 2, is used enable communication between the sensor and the microcontroller. In addition, Nc is pin 3 which free connected and finally is Gnd which is pin 4 for ground in the Arduino [35].

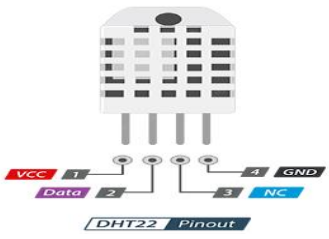


Figure 4. 13: DHT22 Pinout Configuration

DHT22 with Arduino Interface

It is very easy to connect DHT22 to Arduino microcontroller, it plugs in it into breadboard then power the sensor with five volts and enable ground connections and finally connect the data pin into digital pin 2. Which also need to place a pull up resister of 10KΩ between Vcc and data line to keep it higher for proper communication between sensor and Microcontroller [35].

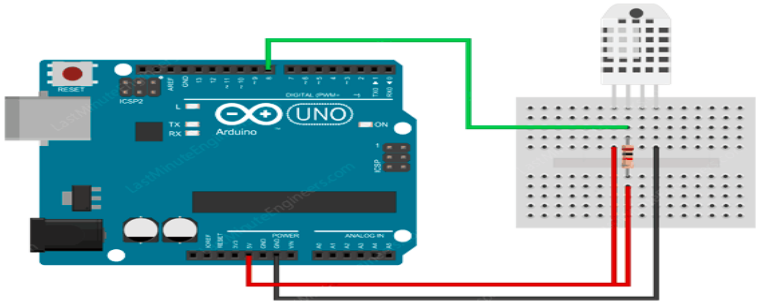


Figure 4. 14: DHT22 with Arduino Interface

Liquid Crystal Display LCD

It is an electronic display module used in various devices and circuits, the module is economically and easily programmable, it can display 16 characters per line and there are 2 such line and each characters displayed in 5x7 pixel matrix. It will be used in the system to provide the output results of the system, when the sensor collects data and analysis it then will be display to LCD for temperature and humidity of the storage area of the cloves. Also, the LCD will be able to display the prediction of color of the cloves by using color sensor [36].

Figure 4. 15: LCD

4.3.3 System Requirements

Those necessity inputs requirements that have been take to accomplish this work. Such as general, functional and non-functional requirements.

General Requirements

The system general requirements include the hardware and software requirements.

a. Hardware Requirements

The hardware requirements include sensor network system that consisting of TCS3200 color sensor that will detect the color of the dried cloves in the field and DHT22 sensor that will determine the presences of water vapour and temperature in a storage cloves storage area. The

Arduino UNO Microcontroller with GSM Wi-Fi module to process data from sensors and send data to the local server through gateway. The Microcomputer at the sometime will be used as a local server to store data. The gateway communication module will be used to communicate between the sensor nodes, local sever and cloud server and the LCD device is for data visualization from the server.

b. Software requirements

The software requirements will consist of ThingSpeak tool to visualize the data from the sensors and the use of Arduino Software (IDE) for codes writing and uploaded to the microcontroller board**.**

4.3.4 Functional Requirements

The main objective of the system is to delivers the quality of the cloves based on three categories. Therefore, the function requirements to archives the system goals are as follows: -

- The system should be able to detect the color of the cloves by using color sensor.
- The system should be able to senses the presence of water vapour and temperature in clove area by using DHT22 sensor.
- The system should be able to predict the quality of cloves based on sensing perimeters.
- The system should be able to send the data to LCD output and IoT cloud platform (ThingSpeak) for analysis and visualization.

4.3.5 No-functional Requirements

It used to describe the ways the system should behave. The following are some of non-functional requirements.

- Availability. The system should be available and operate on all working days.
- Usability. The system should be easy to use by the cloves farmers; cloves evaluate officer and Managements teams.
- Reliability. The system should be well reliable, operate and work with limited constraints that may hinder the working operation.
- Scalability. The system should be grow without negative influences or its performances.
- Power consumption. The system will be operating with the minimum power usage and will conserve the energy.
- Data Integrity. The system should be well secure to protect the data of the farmers.
- Performance. The system should be ensuring optimal responsive ness to a various user's interaction with it at all time.

- Recoverability. The system should be implement with all means of data recovering, such as automatic data backup.
- Flexibility. The architect will be highly describing for future extension of the system.
- Security. Physical and software base security will be including to the system to protect against unauthorised access.

4.3.6 Fuzzy Inference System (FIS)

A fuzzy inference system is machine-learning principles used in prediction analysis for quality of cloves. It is a ruled-based expert system used to produce the output according to the inputs of the system. In this thesis, the fuzzy inference system will be used for analysis and prediction of quality of cloves. The fuzzy logic system used identify the quality of cloves from parameters of color, moisture and temperature in a cloves area. The fuzzy inference system is based on the four main steps, namely; fuzzification, rules base, defuzzification interface and fuzzy logic unit [37].

The fuzzy logic architecture consists of four main parts as Fig.12 shown below.

i. **Fuzzification:** It converts crisp inputs measured by sensors into fuzzy sets and passed into the control system for further processing like color, humidity and temperature.

ii. **Rule Base:** This contains all rules of If-the conditions provided by the experts to control the decision-making system. The fuzzy system provides various methods for designing and tuning of fuzzy controller.

iii. **Fuzzy logic Unit:** It determines the degree of match between fuzzy inputs and the rules created. It determines which rules need to implement according to the given input field based on percentage match. Then, the applied rules are combine to develop the control actions.

iv. **Defuzzification:** This converts the fuzzy sets into crisp value. There are many technical types of defuzzification, so it depends on which one is the best for expert system.

A fuzzy system is implement in the identification of color, moisture and temperature parameters. It is known as a mathematical system that examines input values that are analogue based on the variables from the values between 0 and 1. It can create intelligible and user friendly models of real world system. A control system used for controlling the fuzzy rules that allows the behaviour of the system. Fuzzy interface or controller is known as procedure of mapping, given from input to output with fuzzy logic. Fuzzy logic used to identify the types of quality that depending on the fuzzy rules. The following figure briefly describe the fuzzy logic [37].

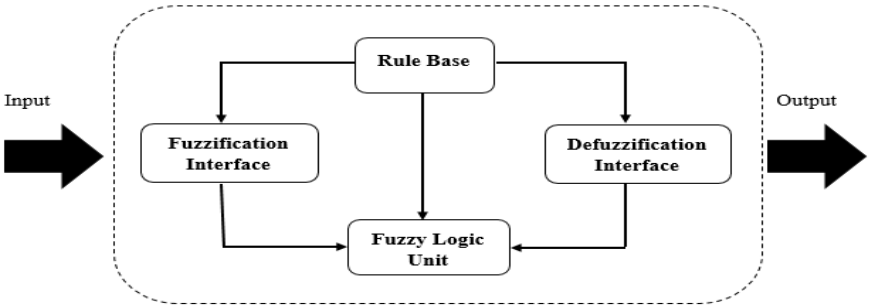


Figure 4. 16: Fuzzy Inference System (FIS)

4.3.7 Membership Function.

The membership function for this work was set and implemented to describe the degree of truth of evaluation quality of the cloves. The rules were set based on three different parameters, which is color intensity, temperature and moisture in the cloves evaluated by output values in percentage.

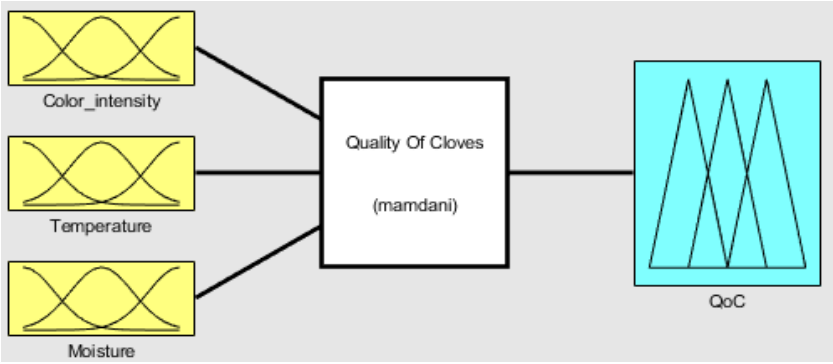


Figure 4. 17: Membership Function

4.3.8 Fuzzy Inputs and Outputs Parameters

The system consists of three inputs parameter variables and one output variable as shown in table 4.7.

Table 4. 7: Input and Output Logic Prediction Perimeters

Fuzzy Input Variables	Input/Output	Prediction Values	Prediction Ranges
Cloves Samples	Input	White. (Poor) Black (Moderate) Brown (Very good)	C B A
Moisture Contents	Input	Poor Moderate Very good	>14% 12% - 14% 6% - 12%
Temperature Contents	Input	Poor Moderate Very good	< 20℃ or >30℃ 20℃ - 24℃ 25℃ - 30℃
Output Results	Output	Third Quality Second Quality First Quality	C / > 14% / <20℃ or >30℃ B / 12% - 14% / 20℃ - 24℃ A / 6% - 12% / 25℃ - 30℃

Table 4. 8: Input and Output Prediction Perimeters of fuzzy system

Fuzzy Input Variables	**Input/output**	**Linguistic Variables**	**Number of Ranges**	**Triangular fuzzy ranges**
Color intensity	Input	Poor	**2.8 - 3.9**	**[2.8, 3.5, 3.9]**
		Moderate	**1.8 - 2.9**	**[1.8, 2.5, 2.9]**
		Very good	**1- 1.9**	**[1, 1.5, 1.9]**
Temperature	Input	Very good	**25 – 30.0**	**[24.8, 27, 30]**
		Moderate	**20 - 24.9**	**[19.8, 22, 24.9]**
		Poor	**10- 20.0**	**[10, 17, 19.9]**
Moisture	Input	Poor	**14 - 15**	**[11.9, 14, 15]**
		Moderate	**12 - 13**	**[10.9, 11.5, 12]**
		Very good	**06 - 11**	**[6, 8.5, 11]**
Quality of cloves	Output	Third Quality	**0 – 70**	**[0, 40, 70]**
		Second Quality	**70 – 90**	**[70, 80, 90]**
		First Quality	**90 - 100**	**[90, 95, 100]**

4.3.9 The Rules of Fuzzy System

The fuzzy system uses a four logic rules to testify the system by using "AND" connectives for the purpose of quality of cloves measurement prediction.

Table 4. 9: The Rules of fuzzy system

No	If					Then
	SAMPLE COLOR		MOISTURE LEVELS		TEMPERATURE LEVELS	CLOVES QUALITY
1	Very good	AND	Very good	AND	Very good	First Quality
2	Moderate	AND	Moderate	AND	Moderate	Second Quality
3	Poor	AND	Poor	AND	Poor	Lower Quality
4	No sample	AND	No sample	AND	No sample	No Sample Detection

4.4 ThingSpeak cloud platform selection

A cloud computing is a large pool of system, connected in public or private network that provide scalable infrastructure and services for application, storage, hosting point, data mining and analysis. This study used the ThingSpeak cloud server for data storage, processing, analysis and notification triggering. ThingSpeak is an IoT analytics open-source platform service that allow users to visualize, combine and analyze real-time data. It uses API to store and retrieve data from things using the HTTP and MQTT protocol over the internet. In addition, it can perform aggregation, visualization and analytics data streams in the cloud [38].

4.5 Arduino Integrated Development

It is an open source software used to write and upload codes to the microcontroller boards such as Arduino boards. The IDE application is suitable for different operating system such as Windows, Mac OS X and Linux. It supports programming languages C and C++. The program or code written in Arduino IDE called sketching and is save with 'ino' extension. In this, study the Arduino IDE version 1.8.19 used.

4.6 MATLAB Software

This is a programming platform designed for engineers and scientist to analyse and design systems and products. The software analyze data, develop algorithm and create models and applications.

4.7 Summary

In the proposed system we have been able to connecting different element and components based on the requirements for data generation, data processing and final provide output results for visualization and analysis.

CHAPTER FIVE

System Prototype and Results Analysis

5.1 Introduction

This section presents the prototype and analysis of the research study, the analysis of the results and system plus the explanations of the results

5.2 System Prototypes

The system prototype and implementation of an "IoT-Based Cloves Quality Evaluation and Control System" are present in this chapter, as well as the considered challenges and limitations that were encountered during the prototype implantation to an output results. The prototype of the system done into three phases. Such as data collection, data processing, communication and displaying the output results.

Data Collection Phase. This is a data input phase whereas TCS3200 and DHT22 sensor are used to collect data from the cloves stimuli sample, in this prototype consist of three sample which named as Sample A, Sample B and Sample C. Each sample defined based on the quality of the cloves. Therefore, sensor collect data from the sample and send it to the Arduino UNO Microcontroller for manipulation and processing. The figure 5.1 shows the different sample of dry cloves.

Figure 5. 1: Cloves Samples

Data Processing and Communication Phase. The phase deal with data manipulation and data communication by collaboration between Arduino UNO Microcontroller and GSM module SIM 800L. Arduino IDE used to implement the source code and then upload it to Microcontroller for data manipulate and process. Then Microcontroller redirect processed data to serial monitor for testing and debugging, LCD for output results as well as to the GSM module for the objectives of transfer to the ThingSpeak cloud platform for analytic and visualization. The phase presents the full prototype designing and components installation that include Arduino UNO Microcontroller, GSM module, sensor and LCD that interlink each other to complete the system prototype. The figure 5. 2 show the full system prototype.

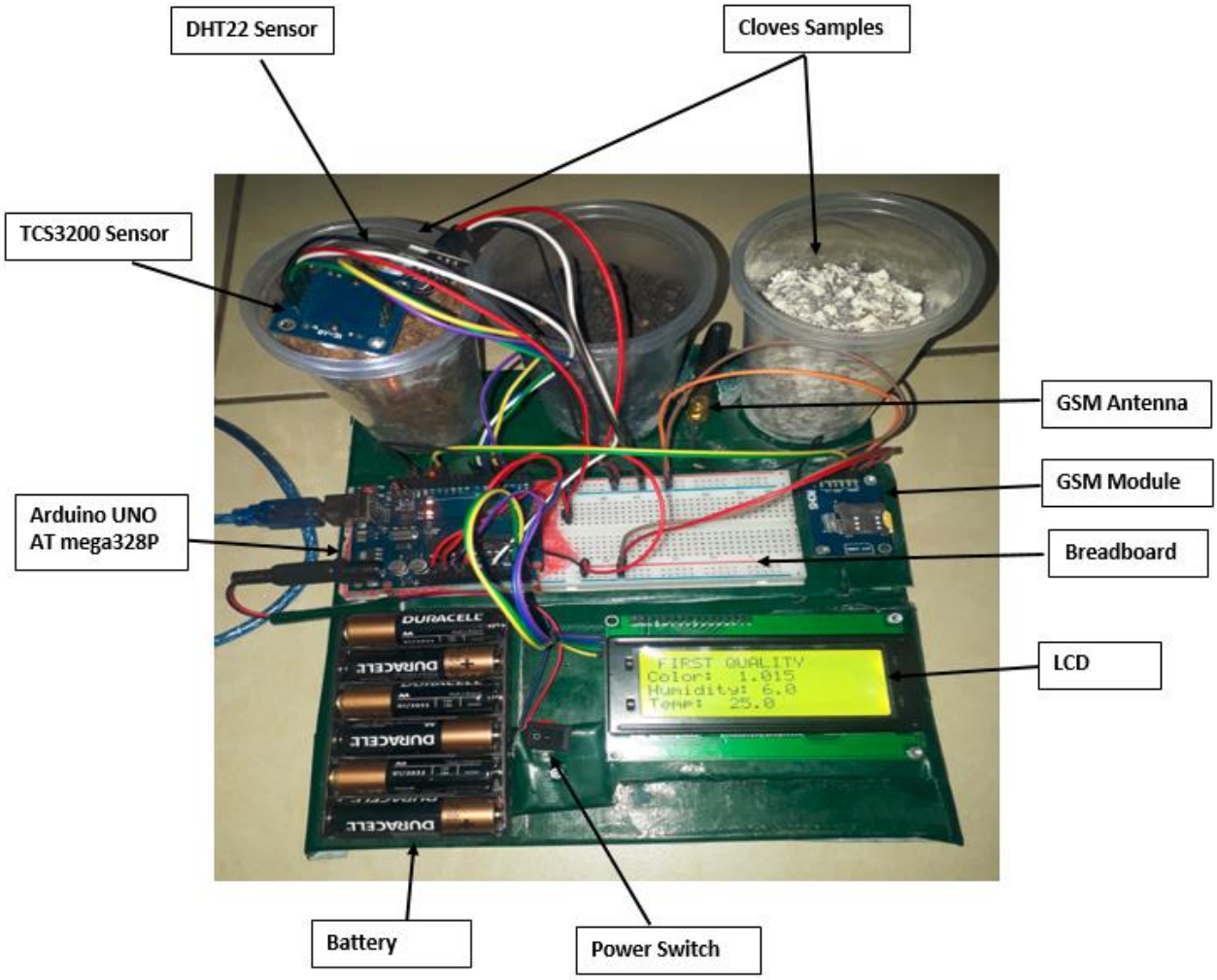


Figure 5. 2: System Prototype

Output Results Phase. Finally, system operation will be tested in the serial monitor, which is built in tool working with Arduino IDE for debugging and error correction. Moreover, the last stage data will display in the LCD and ThingSpeak for data visualization. The figure, 23 show the output results of via LCD and Serial Monitor tool. Also GSM module will send the output data to the cloud for analytic and visualization at the same time send the notification to user through SMS.

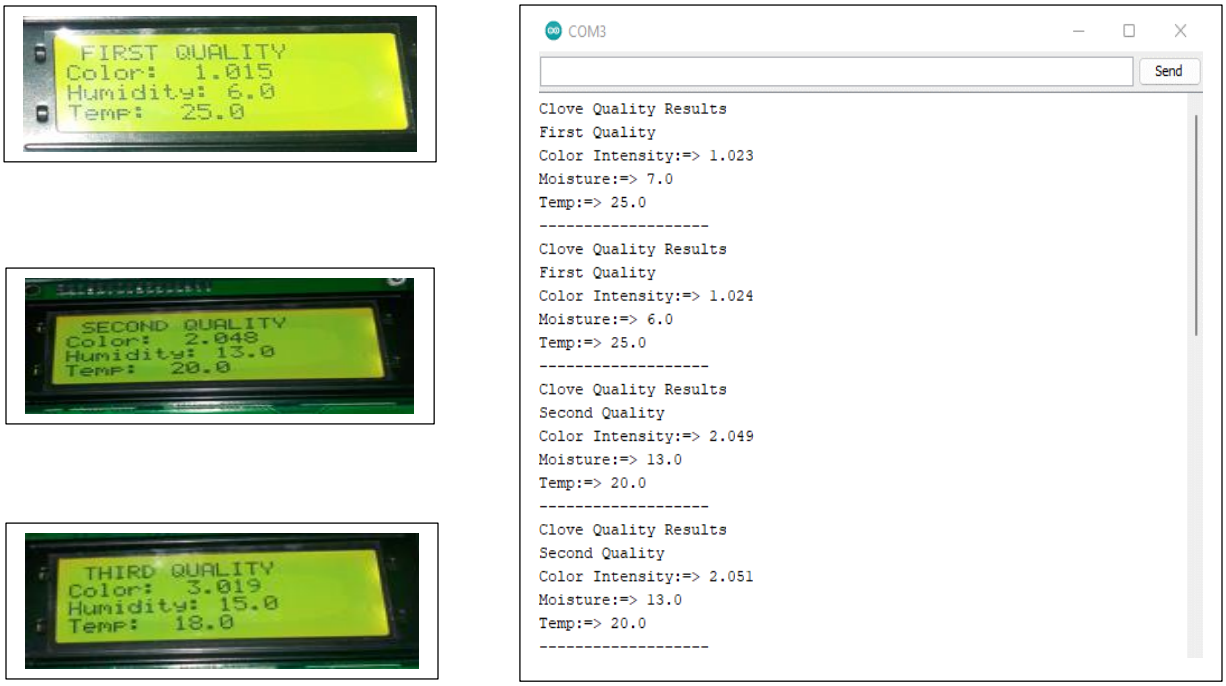


Figure 5. 3: LCD and Serial Monitor tools

5.3 Results Analysis

The table 5.1 shows inputs data collected by using TCS3200 and DHT22 sensors and output results after processing, the input data are RGB color frequencies, temperature and moisture contents and the output data after processing the color frequencies is displayed intensity values as well as temperature and moisture values. The sensor collected data from three main samples of cloves, which are sample A, B and C and then for each sample the sensor read five times. And final provides output results after data processing. The output results, which is intensity obtained from color frequencies, temperature and moisture. Therefore, the output result is core values that will use to make a relationship between temperature and moisture.

Table 5. 1: Data collection

		Input Color Frequencies			Output Temp. And Moisture		Output Intensity
Sample	**5*Reading**	**R**	**G**	**B**	**Temperature**	**Moisture**	**Intensity**
A	1	188	219	204	25.103	7.301	1.016
	2	196	240	223	25.040	7.542	1.005
	3	195	241	226	25.101	7.403	1.003
	4	186	222	205	25.172	7.453	1.011
	5	193	230	213	25.605	6.801	1.011
B	1	218	255	255	20.171	13.201	2.035
	2	230	255	254	20.050	13.121	2.037
	3	220	255	254	20.401	13.012	2.039
	4	220	247	255	20.201	13.401	2.040
	5	225	255	255	20.312	13.310	2.036
C	1	91	94	84	18.301	15.301	3.032
	2	93	96	86	18.121	15.331	3.033
	3	98	103	85	18.256	15.101	3.017
	4	90	93	84	18.331	15.111	3.035
	5	88	91	81	18.213	15.221	3.032

5.4 System performance and accuracy

In order to evaluate the performance and accuracy of the system we decide to calculate the average mean and standardization of the intensity values. The objectives to calculate the mean and standard deviation is to show the operability and functionality of the system in terms of percentages. Intensity values is the core values obtained from color frequencies that will be used to define the quality of cloves in relation to temperature and moisture. The mean value has been obtaining by taking the data collected five times of each sample and divided by the total number of reading. Standard deviation is obtaining by taking the first value of each sample minus the mean values, then for each sample value make square root of each sample [39]. Then enable to make the

summation of each sample. Then divide by fifteen, which is total number of reading. Such as (SUM_SQ, SUM_SQ/14 and SQRT(SUM_SQ/14). The table 11, shows the system accuracies based on mean and standard deviation values.

Table 5. 2: System performance and Accuracy

Sn	Output Results (x)	Mean Results (y)	Power	S. Deviation
1	1.016	-1.0095	1.0190	
2	1.005	-1.0205	1.0414	
3	1.003	-1.0225	1.0454	
4	1.011	-1.0145	1.0291	
5	1.011	-1.0145	1.0291	
6	2.035	0.0095	0.0001	
7	2.037	0.0115	0.0001	
8	2.039	0.0135	0.0002	
9	2.04	0.0145	0.0002	
10	2.036	0.0105	0.0001	
11	3.032	1.0065	1.0131	
12	3.033	1.0075	1.0151	
13	3.017	0.9915	0.9831	
14	3.035	1.0095	1.0192	
15	3.032	1.0065	1.0131	
Total	**2.025**	**0.000**	**10.208**	**0.94**

The formula that used calculate standard deviation are as follows.

$$\text{STD} = \sqrt{\frac{\sum(x-y)^2}{n}}$$

Whereas

STD = Standard Deviation

$\sum$ = Summation

x = Output Results values

y = Mean results

n = Total number of data.

System Accuracy and performance by Percentage.

A = 100% Minus Standard Deviation and Divide by the Total number of data Times 100%

A = 100% - 0.94/15*100%

A = 94%.

Therefore, due to this system accuracy and performance testing it show that eligibility of system operation covers on eligible percent.

5.5 Regression and Correlation Theory

The table 5.3 describe the regression and correlation coefficient between two the variable values. The data obtained by sensors got some challenges of make relationship between variables. Therefore, it is difficult to find the differences between one variable and another to enable us to make a close relationship between intensity, temperature and moisture. For that reason, I have used an alternative method to make the relationships of those variables by applying regression and correlation theory. The theory regression applied purposely to describes numerically related variables to dependent variables, to present linear relationship between two variables and correlation analysis is to determine the association between two variables also to fit the best line and estimate one variables based on another and finally provide a clearer and concise summery of regarding the relation between two variables [40]. MATLAB is a great performance computer language for technical computing. It integrates computation, visualization and programming, the MATLAB application has been apply to make a data analysis and visualization. The equation that can be used to predict and optimize the data set are as follows

$$R = n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right) \div n\left(\sum x^2\right) - \left(\sum x\right)^2$$

$$C = \left(\sum y - R\right) \div N$$

Table 5. 3: Regression and Coefficient Analysis

RX	Y	XSQ	XY
188	1.016	35344	191.008
196	1.005	38416	196.98
195	1.003	38025	195.585
186	1.011	34596	188.046
193	1.011	37249	195.123
958	5.046	183630	966.742

From the table 5.3 above [48], the regression and correlation symbolized as (R), (C) and the obtained values that can enable make relationship between two variables of intensity, and color frequencies are as follows.

The regression value (R) = -0.00093 and Correlation value (C) = 1. 186902

That provide the total of value (X) = 1.186902-0.00092

Table 5. 4: Analysis Quality of the Cloves

Table 5.4 show provide the liner graph of intensity variables, which the core values used to describe the quality of the cloves.

X	Y
0.0	1.186902
0.1	1.186995
0.2	1.187088
0.3	1.187181
0.4	1.187274
0.5	1.187367
0.6	1.187460
0.7	1.187553
0.8	1.187646
0.9	1.187739
1.0	1.187832

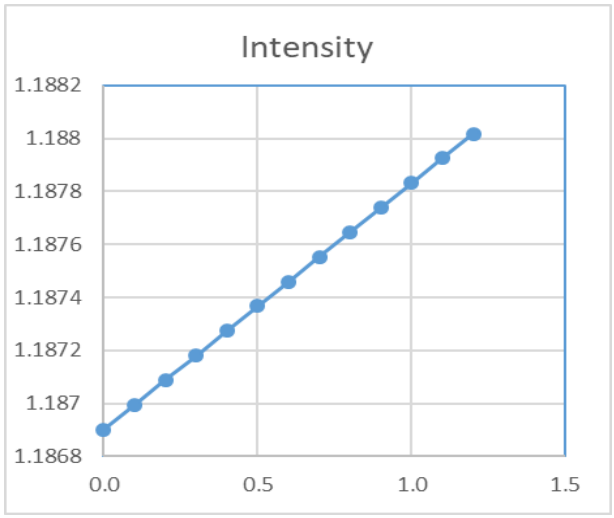


Figure 5. 4: Intensity Analysis

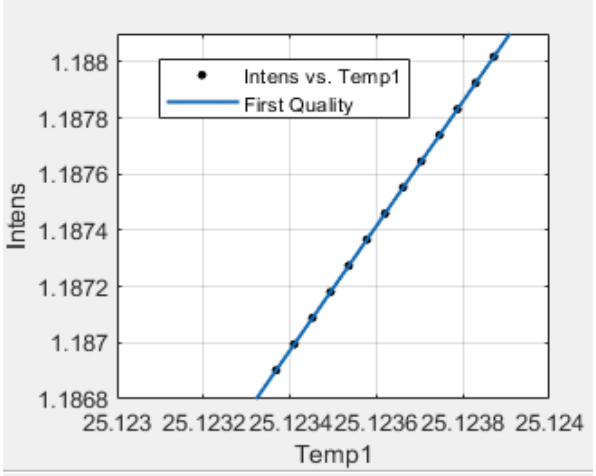
5.6 Relation between Intensity, Temperature and Moisture

By applying the same rule of regression and correlation coefficient for other variables, we have been able to show the relationship between intensity and temperature and moisture. With that logic we have been able to define the quality of the cloves as a first quality this exist due to the interpretation of the parameter values whereas the intensity vales are stand as 1 values parameters, moisture stand as 7.6 level values and temperature is 23℃ value parameters.

Table 5. 5: Relation between Temperature, Moisture and Intensity

Temperature	Moisture	Intensity
25.123	7.657	1.187
25.123	7.658	1.187
25.123	7.658	1.187
25.123	7.658	1.187
25.124	7.658	1.187
25.124	7.658	1.187
25.124	7.659	1.187
25.124	7.659	1.188
25.124	7.659	1.188

Analysis interpretation of the relationship between Intensity, temperature and moisture. Therefore, for that obtained results the graph show the quality of the cloves is "**First Quality**"



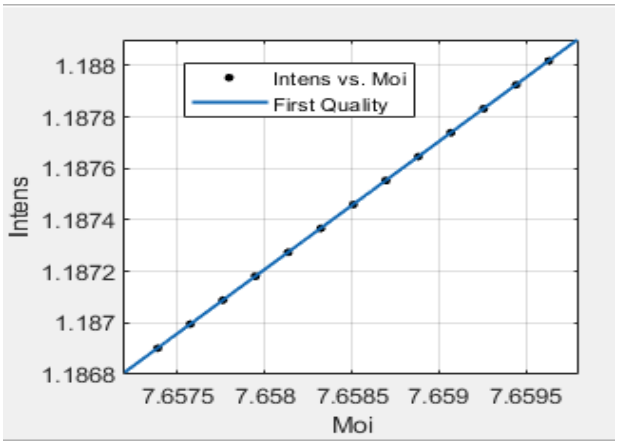


Figure 5. 5: Relation between Temperature, Moisture and Intensity

5.7 Relation between Intensity, Temperature and Moisture

By applying the same rule of regression and correlation coefficient for other variables, we have been able to show the relationship between intensity and temperature and moisture. With that logic we have been able to define the quality of the cloves as a second quality this exist due to the interpretation of the parameter values whereas the intensity vales are stand as 2.1 values parameters, moisture stand as 14 level and temperature is 23℃ value parameters.

Table 5. 6: Relation between Temperature, Moisture and Intensity

Temperature	Moisture	Intensity
23.110	14.048	2.146
23.111	14.049	2.146
23.113	14.049	2.146
23.114	14.050	2.146
23.115	14.050	2.146
23.117	14.050	2.146
23.118	14.051	2.146
23.119	14.051	2.146

Analysis interpretation of the relationship between Intensity, temperature and moisture. Therefore, for that obtained results the graph show the quality of the cloves is "**Second Quality"**

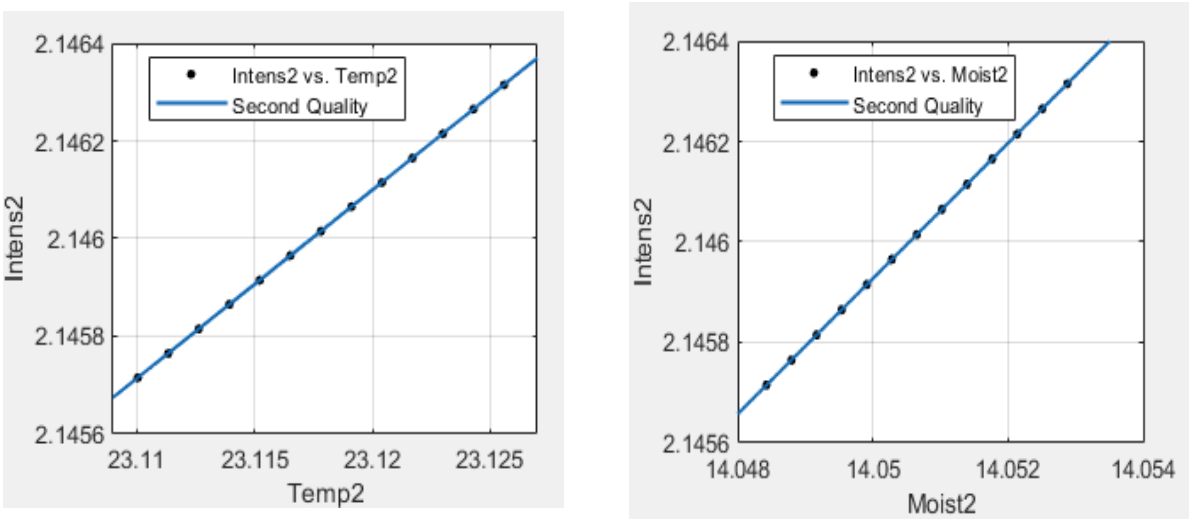


Figure 5. 6: Relation between Temperature, Moisture and Intensity

5.8 Relation between Intensity, Temperature and Moisture

By applying the same rule of regression and correlation coefficient for other variables, we have been able to show the relationship between intensity and temperature and moisture. With that logic we have been able to define the quality of the cloves as third quality this exist due to the interpretation of the parameter values whereas the intensity vales are stand as 3. 1 values parameters, moisture stand as 15 level and temperature is 83°C value parameters.

Table 5. 7: Relation between Temperature, Moisture and Intensity

Temperature	Moisture	Intensity
18.495	15.959	3.180
18.495	15.959	3.181
18.496	15.960	3.181
18.496	15.961	3.181
18.496	15.962	3.181
18.496	15.963	3.181
18.497	15.963	3.181
18.497	15.964	3.182

Analysis interpretation of the relationship between Intensity, temperature and moisture. Therefore, for that obtained results the graph show the quality of the cloves is "**Third Quality"**

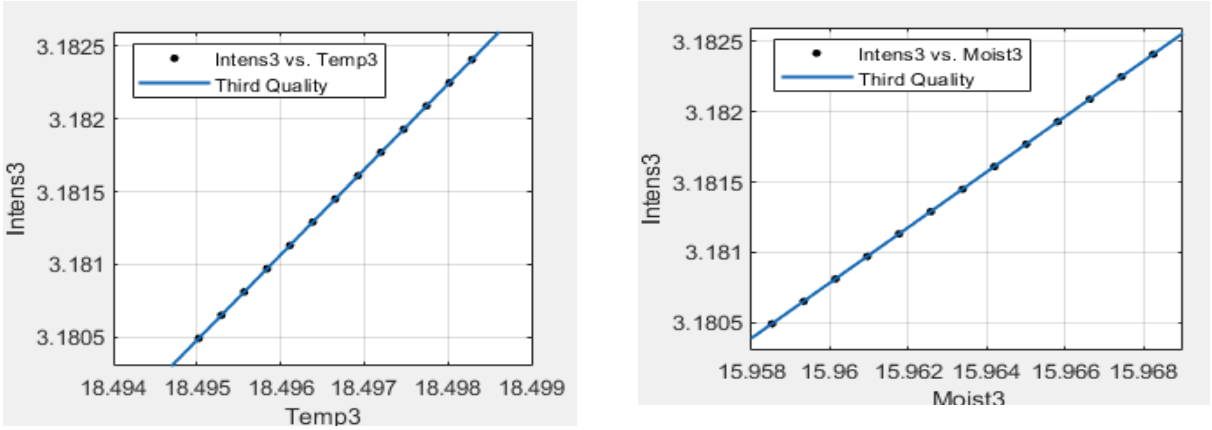
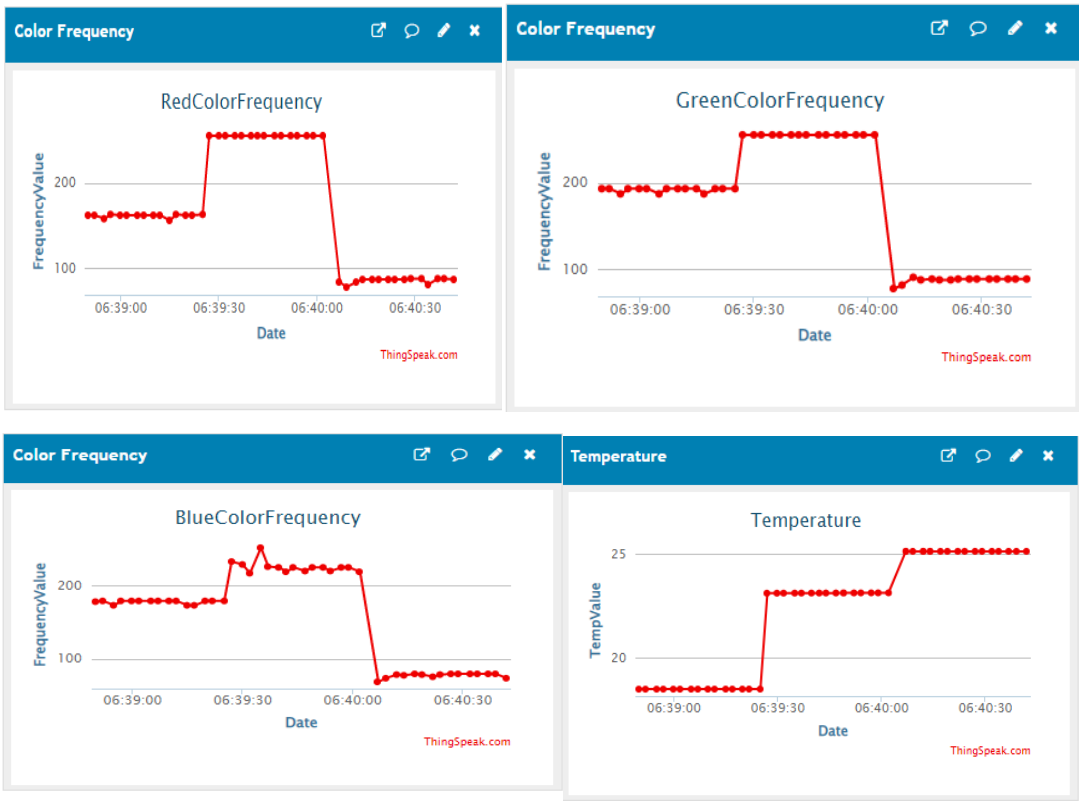


Figure 5. 7: Relation between Temperature, Moisture and Intensity

5.9 ThingSpeak Cloud Analysis and Visualization.

ThingSpeak is an IoT analytics platform services that allows enabling aggregate, visualizing and analyses live data streams in the cloud, data can be send to ThinSpeak from the devices [38]. I, also implement the use of ThingSpeak platform because it creates an instant visualization of live data streaming. Also have it enable long storage of data for future use.



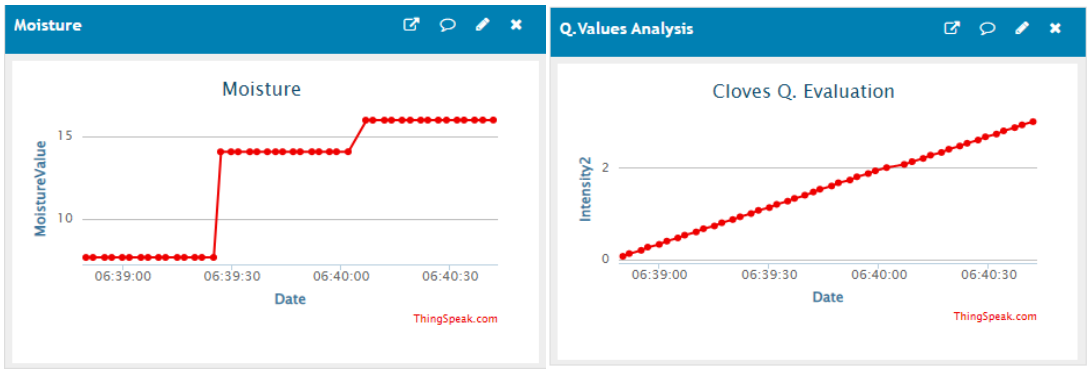


Figure 5. 8: ThingSpeak Data Analysis and Visualization

Visualization Relation between Intensity, Temperature and Moisture.

ThinngSpeak cloud platform has the capability to crate relation visualization graph using built in MATLAB visualization between different input parameters. In this work, we manage either to create relationship graphic visualization between three input parameters. Whereby this also determine the accuracy operation of the system.

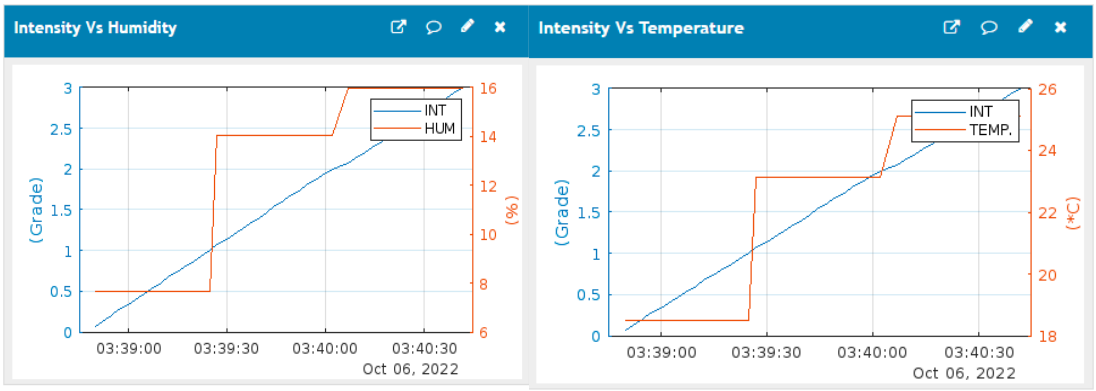


Figure 5. 9: Visualization relation between Intensity, Temperature and Moisture

5.10 Summary

The system was design to evaluate the quality of the cloves, it will bring success to farmers and buyers of the clove because will speed up the evaluation process of the clove and eliminate the complaints that may arise between farmers and buyers of the crop at the time of selling agreements. The prototype has been well designed to be able to evaluate the quality of the cloves automatically, the system will use color and moisture sensors to identify the quality of the cloves. There will be also use microcontroller to process input data and then give output results according to the quality of the cloves. The existence of this system in the cloves production sector will be great achievement to the society that will increase the income of the farmers and also increase the national income.

CHAPTER SIX

Conclusion, Recommendation and Future Work

6.1 Conclusion

The existence of this system will be able to create the loyalty of farmers, and be ready to receive the quality results of their cloves after being approved, either it will contribute significantly reduces slowness quality evaluation processing. The system will be very productive in making the relevant evaluation process of the quality and contribute to the safety of the sale substandard of cloves. Not only that, but also the system will show good sales of cloves at acceptable International Market Standard and will prevent the loss of assets of institutions. Finally, will promote carefully evaluation and control of the cloves. Along with that, the system will be able to solve the problem of passing cloves by visually inspecting them and touching. If the project will be successful implemented, the Cooperation leaders will advices Government Authority due to the huge impact on the development of similar IoT Projects in other Operational Institutions such in Agriculture, Fisheries, Education as well as Infrastructure. Apart from conclusion there some challenges that will be hinder the completion of the project on a time planed whereby the University Management should take into consideration, they have to look twice the financial support provides to their students.

6.2 Recommendation

Based on the findings and experiences during the study I, would like to recommend the following for better results of the proposed system.

- Project need much time and strong financial support in order to develop a better sensor that will be able to detect and identify the real color of cloves themselves without having to calibrate the color frequencies.
- The project will be work better if will be available of suitable moisture and temperature sensor for detecting and reading temperature and water vapour presences in the cloves.
- To continue with the implementation of the system in real-context, the future research they be able to design an algorithm that make a decision for notification based on data prediction in another parameter that will use to identify the quality of the clove.
- To make a prototype other research may use artificial intelligent for data analysis and decision-making.
- Many researchers there have large scope in analysis, design and development of project but most of them are fail at the beginning stages because of poor financial supports.

Therefore, I recommend the management to look widely the finance support they provide to their students.

6.3 Feature work.

Due to the time limit and low finances this project has focused on three parameters that are used in the evaluate the quality of the cloves which is color of the cloves, temperature and moisture contents in the cloves. For further continuing with this project, it should consider other parameters such as – (i). Availability of bugs and dust in the dry cloves, (ii). Rat rubbish in the cloves and (iii). Availability of stones and pieces of irons in the dry cloves**.**

Moreover, the system should consider to provide notification alert to the farms and other cloves industries stakeholder by means of email notification or local call.

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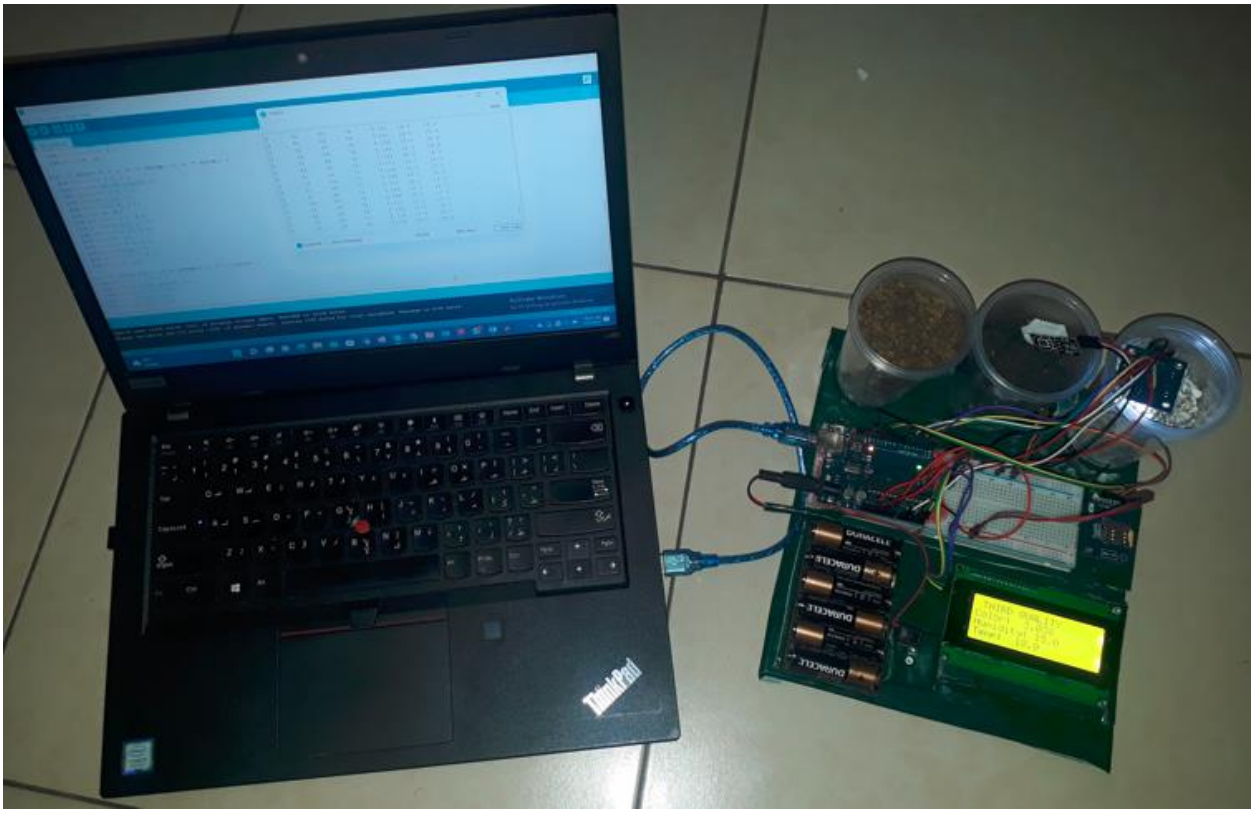
APPENDICES

Appendix 1: System Prototype Installation and Configuration



Appendix 2: IoT-Based Cloves Quality Evaluation and Control System Source Code.

Results Analysis, Relationship Between Intensity and Temperature

```
readChannelID = 1838942;
intFieldID = 4;
tempFieldID = 6;
readAPIKey = 'HHMVKJ6I6B4XMMPM';
[data, timeStamps ] = thingSpeakRead(readChannelID,'Fields',[intFieldID tempFieldID], 'NumPoints',50,'ReadKey',readAPIKey);
intData = data(:, 1);
tempData = data(:, 2);
yyaxis left
plot(timeStamps, intData);
ylabel('(Grade)');
yyaxis right
plot(timeStamps, tempData);
ylabel('(*C)');
legend({'INT','TEMP.'});
grid('on');
```

Results Analysis, Relationship Between Intensity and Moisture

```
readChannelID = 1838942;
intFieldID = 4;
humFieldID = 5;
readAPIKey = 'HHMVKJ6I6B4XMMPM';
[data, timeStamps ] = thingSpeakRead(readChannelID,'Fields',[intFieldID humFieldID], 'NumPoints',50,'ReadKey',readAPIKey);
intData = data(:, 1);
humData = data(:, 2);
yyaxis left
plot(timeStamps, intData);
ylabel('(Grade)');
yyaxis right
plot(timeStamps, humData);
ylabel('(%)');
legend({'INT','HUM'});
grid('on');
```