RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering,
M. Eusebio Avenue, Maybunga, Pasig City

"MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting"

A System Developmental Study presented to the
Faculty of Computer Department College of
Engineering Rizal Technological University
Maybunga, Pasig City

In Partial Fulfillment of the Requirements for the Degree of
Bachelor of Science in Computer Engineering

By:
Engr. Ronel D. Paglomutan

Cabaya, Carlos Anthony C.
Malubay, Keneth A.
Oliveros, Archie Jan E.
Pendre, Dan Joshua L.
Tala, Von Anthony B.

March 2025

APPROVAL SHEETS

This undergraduate thesis entitled " **MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting** " prepared and submitted by Carlos Anthony C. Cabaya, Keneth A. Malubay, Archie Jan E. Oliveros, Dan Joshua L. Pendre, Von Anthony B. Tala, in partial fulfillment of the requirements for the degree, Bachelor of Science in Computer Engineering, has been examined and is recommended for acceptance and approval for Oral Examination.

Engr. Ronel D. Paglomutan
Thesis Adviser

Engr. Rizal C. Laqui
Subject Adviser

Approved by the committee on Oral Examination with a grade of _____ on April 2025.

Engr. Ezekiel C. Nequit
Chairperson

Assoc. Prof. Corazon S. Aspuria
Member

Assoc. Prof. Ma. Felisa Molina
Member

Accepted as partial fulfilment of the requirements for the degree, Bachelor of Science in Computer Engineering

Engr. Christopher L. Zaplan
Chair, Computer Engineering Department

Dr. Corleto R. Bravo
Dean, College of Engineering

ACKNOWLEDGEMENTS

The researchers would want to use this opportunity to express their profound gratitude and appreciation to everyone who has contributed to the completion of this design project. Above all, We appreciate God for giving knowledge, determination, and guidance, as well as for keeping us well and obliging during this thesis-writing journey.

We would also like to thank our friends, participants, and family for their patience, support, and love. Their love and understanding encouraged the creation of this thesis, and their comments and compassion motivated us to succeed. The researchers would also like to thank our professor, who has been with us since the beginning of our journey. Engr. Nequit C. Ezekiel, Engr. Rizal C. Laqui and Engr. Ronel D. Paglomutan for their invaluable guidance, criticism, comments, and encouragement during our research. They are our guiding light as we pursue our academic goals.

ABSTRACT

TITLE : MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting

RESEARCHER : Cabaya, Carlos Anthony C.
Malubay, Keneth A.
Oliveros, Archie Jan E.
Pendre, Dan Joshua L.
Tala, Von Anthony B.

SCHOOL : Rizal Technological University – Pasig Campus

DATE : March, 2025

DEGREE : Bachelor of Science in Computer Engineering

ADVISER : Engr. Ronel D. Paglomutan

INSTRUCTOR : Engr. Rizal Laqui

MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting is designed with a hardware and mobile application that plays a crucial role in presenting data effectively and enhancing user engagement. The system aims to enhance mango quality detection, reduce inspection time, and maintain consistency by developing a system for classifying, grading, and sorting mangoes. The carabao mangoes were processed

in three stages: the hardware weight sensor, which determined the mango's weight; the running conveyor, which used an AI-powered Raspberry Pi camera to detect and classify carabao mangoes; and third stage, The hardware setup for the electronic device utilized an ultrasonic sensor to detect presence, enabling a servo arm to push the mango and rotate containers for sorting based on Carabao mango classification. In addition, the weight sensor will detect both trained and untrained objects to determine whether the weight is classed as mango or not; if not, the object will not advance to the next stage. While the decayed mangoes are thrown in a container and donated to the university garden later on.

The identified carabao mangoes are then sent to the database. The system includes mobile applications with real-time updates and categorized information. The administrator may monitor the system via the mobile application, which provides access to data such as the number of sorted mangoes by class and the merchant data. This enables easy tracking and administration of the sorting process.

Table of Contents

CHAPTER IV: ANALYSIS PRESENTATION & INTERPOLATION OF DATA

CHAPTER V;SUMMARY OF FINDINGS,CONCLUSION & RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

APPENDICES

CHAPTER I

THE PROJECT AND IT'S BACKGROUND

1.1 Introduction

Innovation is described as the development and implementation of new or improved technologies, techniques, systems, and processes that result in significant advances or breakthroughs in a variety of fields (Jain N., 2023). Exploring the frontiers of technology, it illuminating the transformative potential of emerging technologies and the potential of new technologies. Image processing, robotics, and the Internet of Things are some of the emerging technologies used in prototyping various systems currently in development.

Image processing, machine learning, and the internet of things (IOT) are among the technologies that can be applied to AI as techniques grow more varied and new approaches in the field of soft computing emerge, according to the article of (Nwaojigba G., 2023). Image processing is converting a picture into a digital format and conducting various operations on it to extract usable information from the image. The Internet of things (IOT), is a network of physical devices, like mobile applications used to communicate, It enables these objects to connect and exchange data, according to the article of (Greengard S., 2025). AI refers to computer systems that can do functions that normally require human intellect, such as thinking, learning,

perception, and language comprehension. These systems analyze large databases, identify patterns, and make judgments at unparalleled speeds and precision according to (International Organization for standardization, n.d.).

The researchers system development integrates various technologies into the prototype like Artificial Intelligence (AI) and Internet of things (IOT) combined system for mango sorting using image processing. The goal is to enhance the quality detection of Carabao mango by integrating Artificial Intelligence (AI) Internet of Things (IOT), image processing (IM), and machine vision (MV) in the prototype. The devices communicate with each other to accurately sort mangoes according to their weight, size, and quality. The prototype use image processing to enhance and interpret captured images. The use of AI algorithms enables the system to manage large volumes of visual data gathered via cameras. convolutional neural networks (CNNs) are used to identify each mango in front of the camera. quality evaluation models are employed to detect flaws in the mangoes.

The researchers system used yoloV8 and OpenCV libraries to determine color and quality. Yolov8 object tracking is transforming real-time tracking and analysis of moving objects in the field of computer vision according to (Ghosh A., 2024), The OpenCV library plays an important role in allowing developers and researchers to leverage the benefits of visual

data processing, according to the author (Alake R., 2024). The weight sensor is employed in the sorting process to categorize carabao mangoes according to their weight, this sensor can be combined with other technologies like image processing to provide a more thorough and accurate evaluation of the mangoes. The use of image processing, which involves grading the mangoes based on their outside appearance and determining color through RGB color recognition. The RGB color model is a regarded as an additive system since it generates a wide variety of colors by combining the wavelengths of the main colors red, green, and blue according to (Zelazko A., 2025).

Raspberry Pi and arduino microcontroller-based systems, integrate in mango sorting system, have been developed with connected devices like camera, sensors, and motors. Mangoes are moved by conveyor belts equipped with sensors and actuators.. Arduino can control conveyor belts, and carabao mangoes can be detected and classified using computer vision techniques with the use of raspberry pi that serve as the control center, while a mobile app serve as the display panel of data. through a serial connection, arduino may receive commands from raspberry pi to start or stop the conveyor belts. Implementing the system, to enhance the quality detection of mangoes, and to increase sorting productivity, which are the goals of an MangoQ: An AI-Based System for Carabao Mango Quality Detection and

Sorting, by utilizing advanced technologies like Artificial Intillegence (AI), machine vision (MV), image processing (IM), and the internet of things (IOT), mango sorting processes can revolutionize our farmers to have this device and aid our agricultural advancement regarding sorting carabao mangoes.

1.2 Background of the Study

According to the report of (Jagdish., 2024), Mangoes in the Philippines have enormous market potential for both domestic and foreign exports. Mango growers can make between P100,000 and P500,000 per hectare annually from this high-value commodity. A centennial crop, mangoes can help families for three or more generations. In the main mango-growing regions of the Ilocos, Central Luzon, and Western Visayas, fewer than 7 million mango trees have been planted on roughly 158,000 hectares. Around the world, the Philippine mango (National Fruit) is regarded as the best-tasting carabao mango. Ninety-five percent of the 1 million metric tons of mangoes produced annually in the Philippines are consumed domestically, while the remaining five percent are exported, bringing in about US$35 million for the nation each year.

According to (Flowerree.,2020), Mangoes are sorted in the Philippines according to their marketable quality, degree of skin cleanliness, size, weight, and absence of infestations and diseases. The sorting process involves a variety of techniques, including hand picking, the use of picking

poles and ladders, rigorous grading, and sorting in accordance with predefined standards. AI-Based System for Carabao Mango Quality Detection can eliminate the need for manual sorting processes, and the use of artificial intelligence for mango sorting can provide accurate and consistent results, improving overall mango quality detection and efficacy, this assures that high-quality mangoes are sold to customers, boosts farmer and exporter profitability.

AI-Based system for carabao mango quality detection are the good approaches for detecting quality of mango. According to the article of (Zhou et al., 2023), on- farm sorting and transportation of post-harvest fruit includes removing defective items, rating them into quality categories, distributing them into bins, and transporting bins to field collection stations, (AI) can considerably minimize post-harvest losses by speeding up on-farm sorting while maintaining high accuracy and robustness. AI is essential for improving fruit identification accuracy, increasing productivity, and promoting economic growth. Sorting is made easier by algorithms, which use electronics and sensors to classify data quickly and accurately.

High mistake rates are a result of subjective categorization and inaccurate sizing, which give rise to current sorting inefficiencies. Through the analysis and grading of mango properties, utilizing machine vision and machine learning improve sorting accuracy. The necessity for AI and

machine vision education is emphasized by the ongoing difficulties with technology adoption and awareness gaps. The goal of AI-Based system for carabao mango quality detection is to support agriculture by encouraging future production and breakthroughs. The system faces challenges like time-consuming tasks, grading errors, subjective grading, inability to detect outside defects, and excessive labor for sorters. The stages of ripeness of the carabao mango depend on its color, the stages are green, breaker, turning, ripe, and overripe. carabao mangoes have different stages of ripeness, according to (PNS-BAFPS 13-2004 PHILIPPINE NATIONAL STANDARD, 2004), The green stage is completely light green, while the breaker stages are traces of yellow, while the turning stages are more green than yellow, while the ripe stages are 80%–100% yellow than green. In decay, it will be known when it has mold or other unusual changes in the color of the skin. Having a larger dark spot in the mango is an indication that it is decaying. dark spots on mangoes may indicate bacterial black spot disease caused by the bacterium Xanthomonas campestris pv. mangiferae-indicae. Some spot may be caused by physical injury or other disorders. The raw mango is known when it is green in color, and smaller than ripe mangoes.

According to (PNS-BAFPS 13-2004 PHILIPPINE NATIONAL STANDARD, 2004), The extra-large carabao mango weighs over 350 grams, the large weighs between 300 and 349 grams, the medium weighs between

250 and 299 grams, the small weighs over 200 to 249 grams, and the super small weighs 160 to 199 grams. Ilocos region produce more mangoes with a production of 122.30 thousand metric tons, or 20.5% of the total, the Ilocos Region was the leading mango producer at that time. Mango production in Central and Western Visayas was 89.76 thousand metric tons and 55.10 thousand metric tons, respectively. 44.8 percent of the nation's mango production came from these areas according to the report of (psa.gov.ph, 2023), Mango plantings from January to June 2023 covered 184.03 thousand hectares, a small reduction from the same period the previous year.

Carabao mangoes standard that the mangoes must meet certain requirements, including being mature and in good shape, being reasonably clean, being free of diseases and insects, and not having any injuries. Product quality is crucial in the market, first of all, it helps create a positive reputation and fosters client trust. Businesses need to prioritize product quality since it has a direct impact on customer happiness, brand recognition, and market performance. Businesses can achieve long-term growth and success by concentrating on quality, which will also help them gain more trust from their customers, enhance customer loyalty, and generate larger revenues and profits. It is crucial to adhere to national standards for this reason.

1.3 Statement of the Problem

The problem that the system is facing is how it can sort consistent, accurate, and reliable grading of carabao mangoes based on weight, size, and quality, and one of the problems is how to avoid the grading error and make a mobile application for data presentation of carabao mangoes and mango merchant data.

Specific Problems

It's main objective was to respond to the following questions:

1. How will the system distinguished between ripe, unripe, and decaying mangoes?
2. How will the device classify the quality of harvested Carabao mangoes?
3. How can the Carabao mango sorting systems be evaluated in terms of system operability, Consistency, Accuracy and Efficacy??

1.4 Objective of the Study

This study aims to enhance mango quality detection, reduce inspection time, and maintain consistency by developing a system for classifying, grading, and sorting mangoes using machine vision, physical appearance, and size.

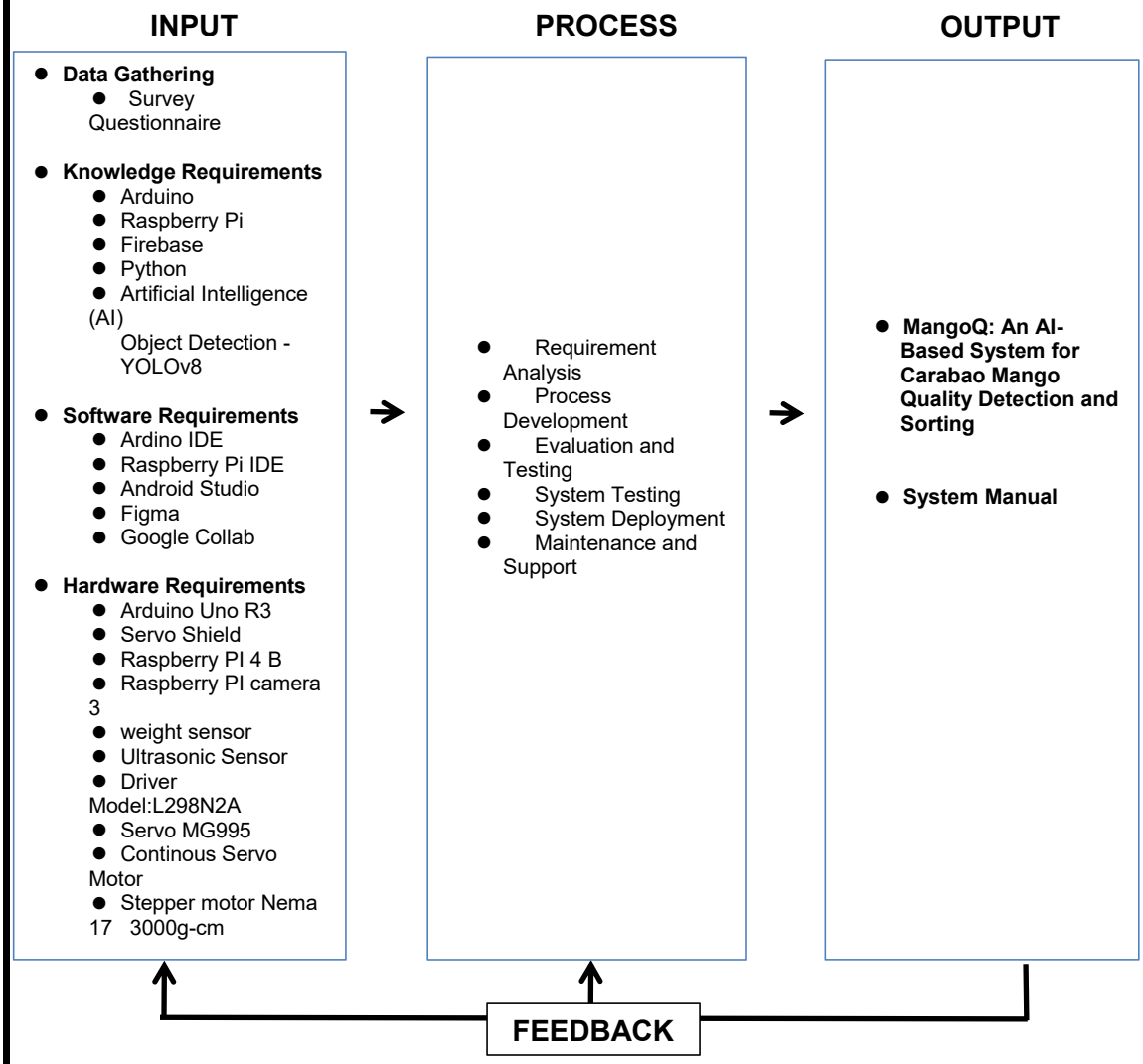
Specific Objectives

The objectives involve the use of artificial intelligence that distinguishes the quality of the harvested carabao mangoes to solve the problem of the system.

1. To develop innovative artificial intelligence for quality detection and sorting for carabao mangoes.
2. To design a system that uses artificial intelligence algorithms to sort and classify carabao mangoes based on their quality.
3. To test and evaluate the system's operability, consistency, accuracy, and efficacy to address the challenges associated with the system.

1.5 System Design Paradigm

Figure 1.1 present how the proponents did the research conception to solve the identified problem and provide an acceptable solution using the system development Input-Process-Output (IPO).



1.1 IPO of the" MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting"

Figure 1.1 illustrates the System Design Paradigm. The input phase involves collecting data and identifying the necessary requirements, including knowledge, software, and hardware essential for developing the design project. The process phase encompasses the creation of the project, which includes

testing various system components and functions, gathering feedback from respondents, deploying the system, and ensuring continuous support and maintenance for optimal performance. The final output is a prototype named MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting.

Data Gathering – A survey questionnaire is used to collect insights from professionals in the carabao mango industry to identify challenges in the sorting process, evaluate the potential for AI integration, and ensure alignment with the Philippine National Standards for fresh fruit. The questionnaire addresses current sorting methods, system needs, and perceptions of automation. The collected data guides the development of the system, aiming to enhance its operability, consistency, accuracy, and Efficacy.

Knowledge Requirement – This stage focuses on acquiring the necessary technical expertise to develop the mango sorting system. Proficiency in Arduino is essential for controlling microcontrollers, enabling precise motor operations and efficient sensor data acquisition. Understanding Raspberry Pi is crucial, as it serves as the main processing unit, handling AI models and facilitating real-time decision-making. Python programming skills are fundamental for developing system logic, integrating hardware components, and processing image and sensor data. Knowledge of firebase is required for

effective database management, allowing for efficient storage and retrieval of sorting data to monitor system performance. Additionally, expertise in Artificial Intelligence, particularly in object detection using YOLOv8, is necessary for training and deploying models that accurately classify carabao mangoes based on established quality standard.

Software Requirements – This phase outlines the essential software tools necessary for coding, AI model training, and system testing in the development of the mango sorting system. Arduino IDE is essential for writing and uploading code to the Arduino Uno R3, enabling precise control over sensors and motors involved in the sorting process. Raspberry Pi IDE Plays a crucial role when working with a camera module on a Raspberry Pi, providing the tools needed to write, test, and run code that controls the camera, facilitating image capture for quality assessment. Figma Utilized for designing the application's user interface and user experience (UI/UX), ensuring an intuitive and user-friendly design. Android Studio employed for developing the actual application, including coding and building, to create a functional and responsive mobile app. Google Collab a cloud-based platform that facilitates AI model training by leveraging its computing power to process large datasets, streamlining the development of machine learning models for mango quality detection. These software tools collectively support the development, testing, and deployment of an efficient and effective AI-based

mango sorting system.

Hardware Requirements – This section details the physical components essential for the operation of the AI-based carabao mango sorting system. Arduino Uno R3 and Raspberry Pi 4 serve as the primary controllers, managing inputs from various sensors and executing sorting decisions. Raspberry Pi Camera Module Captures high-resolution images of carabao mangoes, facilitating AI-based classification based on visual features such as color. Weight Sensors: Measure the weight of each mango to ensure compliance with grading standards, contributing to accurate classification. Ultrasonic Sensors: Detect the presence of mangoes on the conveyor belt, enabling real-time monitoring and coordination with the sorting mechanism. Servo Shield: Allows for efficient control of multiple servo motors, streamlining the management of mechanical movements within the system. Servo Motors and Continuous Servo Motors with Servo Arms manage precise movements required for sorting, directing mangoes into appropriate categories based on the AI's classification. These hardware components work in unison to automate the sorting process, enhancing operability, consistency, accuracy, and Efficacy.

Process – This stage encompasses all activities and operations necessary to transform the gathered inputs into the desired outputs.

Requirement Analysis – This phase centers on identifying and defining the

problem to be addressed. It involves gathering information about the system's expected functionality, performance criteria, and technical constraints. This includes analyzing industry standards, understanding user needs, and determining the essential components required for development. Feasibility studies are conducted to assess potential challenges and define the system's scope, ensuring alignment with the desired objectives.

Process Development – This phase involves designing a conceptual prototype based on the identified requirements. Theoretical considerations include defining the system architecture, outlining data flow, and planning the interaction between software and hardware components. A functional model is developed to simulate how different components will work together. This phase focuses on theoretical discussions about how object detection, data processing, and decision-making mechanisms will be structured without actual implementation. The goal is to establish a blueprint that can be used for testing and refinement.

Evaluation and Testing – This phase involves conducting simulations, identifying potential errors, and validating the effectiveness of the system's logic. Various testing methodologies, such as accuracy assessments and performance benchmarking, are employed to refine the system. Identified errors and inefficiencies are addressed through modifications, ensuring continuous improvement. The primary goals of this phase are to identify

defects, validate that the system meets specified requirements, and verify optimal performance under various conditions. By systematically addressing issues uncovered during testing, developers can enhance the system's reliability and effectiveness before full-scale deployment.

System Testing—This phase involves a comprehensive evaluation of the prototype to ensure all components function cohesively. It includes system integration testing to verify seamless interaction among modules, as well as theoretical stress tests and failure analysis to predict system behavior under various conditions. Key testing criteria encompass response time, accuracy, and overall reliability, contributing to the refinement of the system's functionality and stability.

System Development—This phase focuses on strategizing the implementation of the system, ensuring its compatibility with existing processes, and addressing potential scalability challenges. Deployment plans are formulated to facilitate the system's integration into real-world environments, aiming to minimize disruptions and provide user training for effective operation. The primary objective is to prepare the system for operational use. Effective deployment planning is crucial for the successful introduction of a new system. It involves identifying necessary resources, outlining tasks, establishing timelines, and assessing potential risks to ensure a smooth transition from development to production.

Maintenance and Support – This phase emphasizes planning regular updates, resolving potential issues, and enhancing system efficiency over time. Implementing long-term maintenance strategies ensures the system remains reliable and adaptable to evolving requirements and technological advancements. Collecting regular feedback aids in refining future versions, thereby ensuring the system's sustainability and long-term usability. Effectively managing maintenance and support enhances user satisfaction, extends the system's lifespan, and ensures alignment with evolving business objectives.

Output – This term refers to the final products or results generated after a system has processed its inputs.

MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting - The MangoQ system introduces automation in the sorting of Carabao mangoes based on weight and quality, enhancing efficiency in the mango processing sector. By leveraging artificial intelligence, the system aligns with the Philippine National Standard for fresh fruits, ensuring high compliance. This AI-driven approach not only accelerates the sorting process but also minimizes human error, leading to increased productivity and improved overall processing **quality.**

System Manual - Contains user guides for the user, might offer relevant information on system and functionalities.

1.6 Scope and Delimitation

The Enhanced AI-Powered Carabao Mango Sorting System is developed to provide precise and automated sorting, promoting consistency in data handling to enhance overall productivity. Purpose-built for mango sorting processes, the system is designed to align with both user expectations and market standards. This research aims to improve the accuracy of Carabao mango quality detection by incorporating essential parameters such as weight and classification grades. By optimizing the sorting workflow, the system intends to simplify and improve the grading process for farmers and industry professionals alike.

The following are the system capabilities:

It is specifically engineered to identify and sort Carabao mangoes according to their unique weight and quality classifications, in accordance with the Philippine National Standard for fresh fruits such as.

Table 1.1 Standard of Carabao Mango

Carabao Mango Quality Classification Table

Stage	Color	Class	Spot Condition	Size	Weight (grams)
Ripe	Light Yellow	Extra Class	A - No Spot	Large	300 - 349
	Greenish-Yellow	Class I	B - Little Spot	Medium	250 - 299
			C - Medium Spot	Small	200 - 249
Breaker	Green-Yellow	Class II	D - Large Spot	Medium	250 - 299
				Small	200 - 249
Raw	Green	N/A	No visible defects	Medium	250 - 299
				Small	200 - 249
Decay	Deep Yellow/Darker	Class III	E - Wrinkled Spot	Large	300 - 349
			F - Dark Spot	Medium	250 - 299
				Small	200 - 249

This classification system is designed to sort produced based on quality, stage of ripeness, size, and condition, with the primary purpose of ensuring consistent product quality for consumers and streamlining the sorting process for retailers or wholesalers. The quality categories range from "ripe" with no spots to "decay," indicating the fruit's condition, which helps identify the fruit's condition, which helps indentify fruits suitable for sale or processing. The stage of ripeness, from " A - No spot " (ripe) to "F - Dark spot " (decayed), provides a clear assessment of the fruit's freshness and suitability. Class further refines the categorization, with Class 1 representing the ripe, Class II

breaker, class III for decayed produced. Size categories based on weight (large, medium, small), help ensure uniformity and meet market demands. This table is essential for effective inventory management, quality control, and meeting consumer expectation for fresh produce.

System limitations and Delimitation

The System's limitation is that it can only process carabao mangoes. The system only detect the Unripe, Ripe and decay mangoes. The system only operates when there is stored power. It can detect if a mango is rotten but cannot identify when it starts to spoil. It cannot inspect the inside of the mango; it can only analyze it's external appearances. The system uses a manual cleaning; the farmers need to clean the carabao mango before they put it on the system to avoid any bacterial infection. The mango need to be put at the center of the weight sensor to get the data of its weight, The procedure for replacing the mango container is manual; farmers must change the container before it is full. The system includes a mobile app that will function as a data list presentation. The system can detect any object, even if it's not a mango. The system's artificial intelligence only focuses on the skin color of the object, not the shape of it, so any object can be sorted by the system.

1.7 Significance of the Study

This work is significant because it has the potential increase sorting

process quality detection and accuracy, and stimulate innovation in the area of agricultural technology. The following are the people who will be benefited from the newer system:

To the Consumers – by acquiring high-quality mangoes that adhere to the necessary criteria for ripeness, size, and form, consumers can benefit from an AI mango sorting system.

To the Exporters – an AI fruit quality detection mango sorting system can help exporters by verifying that the mangoes fulfill the requirements necessary for export, increasing the speed and precision of the sorting process, and minimizing waste.

To the Food processing companies – Food processing companies can benefit from an AI fruit quality detection mango sorting system by ensuring that the mangoes meet the required standards for use in different food products, improving the efficiency and accuracy of the sorting process, and reducing waste.

Fruit and vegetable Farmers – Fruit and vegetable Farmers can benefit from an AI fruit quality detection mango sorting system by improving sorting effectiveness, reducing labor costs, and raising production.

To the future researchers – This research study would help future researchers be aware and knowledgeable of the processes involved in

artificial intelligence-based fruit quality detection and sorting, plus it would serve as a reference for future researchers.

1.8 Definition of Terms

The terms listed below are defined by the proponents in the ways of their understanding and how they used it in this document.

Artificial intelligence – A collection of technologies known as artificial intelligence (AI) allows computers to carry out a range of sophisticated tasks, such as the ability to see, hear, and translate spoken and written language, analyze data, make suggestions, and more.

Automated – Automated tasks are those that are completed by machines, computers, or other technologies instead of humans. Automated tasks entail the use of established decision criteria, sub process relationships, and related actions that are implemented by machines.

Autonomous – refers to responding, reacting, or developing independently of the whole, denoting or performed by a device capable of operating without direct human control.

Breaker Stages – Breaker is the stage of ripeness of carabao mango, with streaks of yellow as an indication.

Contamination – A substance, physical body, natural environment, workplace, etc. is contaminated when it contains an unwelcome or undesired ingredient

that taints, corrupts, infects, renders it unfit, or degrades it.

Consumers – One who acquires or utilizes goods and services for personal, social, familial, home, and similar reasons rather than for business ones is referred to as a consumer.

Decay Carabao Mangoes – Weight loss, softness, vitamin C degradation, and deterioration all occur during postharvest preservation. Furthermore, tissue breakdown caused by a freezing injury might result in the fruit developing black scald-like discolouration and brown spots.

Exporters – The term "exporter" is frequently used in the context of international trade, where goods and services produced in one country are sold to consumers in another country. An exporter is a person, nation, or corporation that sells goods or services to another country.

Food processors - Food processors frequently have a variety of features and capabilities, including varied speeds, blades for different purposes, and options for slicing and shredding. Several variants also come with dishwasher-safe components for simple cleaning.

Green Stages – green is the stages of ripeness of carabao mango the indication is got completely light green color,

Machine Vision - Computers and other machines can now observe, analyze, and interpret visual data from their surroundings thanks to a technology called

machine vision. In order to process and analyze images, it uses one or more video cameras, analog-to-digital conversion, digital signal processing, and a combination of hardware and software.

Physical strain – Physical strain is the term for the force or influence that pulls, strains, or presses something, occasionally causing pain or injury.

Postharvest – The stage of crop production known as postharvest includes cooling, cleaning, sorting, and packing and occurs right after crop harvest. A crop starts to degrade the moment it is pulled out of the ground or split off from its parent plant, and postharvest handling primarily affects the crop's final quality.

Processing Companies – Companies that handle the processing, production, and distribution of food items are known as food processing companies.

Quality Detection – The process of identifying and assessing the quality of a good, service, or image using a variety of methods and technologies is known as quality detection. Assuring that the product or output adheres to the desired standards and specifications is the aim of quality detection.

Ripe – Ripe refers to the carabao mango's ripening phases, which are indicated by 80% to 100% yellow color.

Raw Carabao Mangoes – When raw, the mangoes are known for their delectable flavor and are normally sweet with a hint of green**.**

Ripe Carabao Mangoes – The fruit is green-tinged bright yellow in color, with rich yellow flesh that melts softly and has a strong aroma**.**

Turning Stages– Turning is the stages of ripeness of carabao mango the indication is more green than yellow.

CHAPTER II

REVIEW OF RELATED LITERATURE AND STUDIES

The chapter lists the many academic works and research that were done. want the research to become more acquainted and comparable to the current study.

2.1 FOREIGN LITERATURE AND STUDIES

This section contains international works of literature and studies that researchers used to gather knowledge and ideas for their thesis.

2.1.1 Advancement in artificial intelligence for on-farm fruit sorting and transportation

According to the article of Zhou et al. (2023), During on-farm sorting and transportation, postharvest fruit must be separated from faulty products, classified into categories according to quality, distributed into bins, and transported in bins to field collection stations, developments in artificial intelligence (AI) can speed up on-farm sorting and transportation with high accuracy and resilience, thereby significantly reducing postharvest losses. The primary objectives of this literature review are to provide a comprehensive overview of AI applications for fruit sorting and transportation on farms, to analyze those applications critically, and to highlight both their advantages and disadvantages. The challenges of on-farm sorting and transportation were looked at in order to determine the function of AI.

To demonstrate the tasks that AI models have handled for on-farm sorting and transportation, sensors and data collection methods were examined. In order to compare the appropriate methods for on-farm sorting and transportation, AI models that had been developed in earlier studies were examined. Finally, the benefits and drawbacks of using AI have been examined, and a thorough analysis has been given to suggest areas for further research. This survey is expected to open the door for additional research on the use of automated devices or on-farm fruit sorting and transportation.

2.1.2 Machine Vision Based Techniques for Automatic Mango Fruit Sorting and Grading Based on Maturity Level and Size

Nandi et al. (2013), in the recent years have seen an increase in the potential and significance of autonomous vision-based technologies in a variety of disciplines, including agriculture and the food business. This article discusses an autonomous system that uses electronic vision to sort and grade fruit like mango (Mangifera indica L.) according to their size and level of maturity.

The use of automatic vision-based systems was intended to replace human methods for sorting and grading fruit since manual inspection makes it difficult to maintain grading consistency and sorting uniformity. A prototype

electronic vision-based automatic mango sorting and grading system employing fuzzy logic is explored as a way to speed up the procedure while maintaining consistency, uniformity, and correctness. The automated system gathers video images from a CCD camera mounted on top of a conveyer belt that is transporting mangoes. It then processes the images to gather a number of pertinent attributes that are sensitive to the mango's size and maturity level. For the purpose of predicting maturity, the Gaussian Mixture Model (GMM) is employed to estimate the parameters of the various classes. The mango's binary picture is used to calculate its size. Last but not least, mango fruit is automatically sorted and graded using fuzzy logic approaches.

2.1.3 Mango Classification System Based on Machine Vision and Artificial Intelligence

Thinh et al. (2019), Mangoes can be sorted and classified according to their color, weight, size, shape, and density. Currently, classification based on the aforementioned characteristics is primarily done by hand since farmers are aware of the low accuracy, high expenses, negative health impacts, and high costs associated with expensive and economically inferior methods. The mango's interior characteristics, such as sweetness, hardness, maturity, and brittleness is very important, yet it can only be estimated by external or subjective analysis. In order to tackle this issue, artificial neural networks must be used. To determine the best and most accurate technique of mango

categorization, this study focused on the three primary commercial mango species found in Vietnam.

Mango categorization investigations on a global scale have not yet been implemented in practice but are practically complete in the lab, mango fruit quality assessment remains unresolved. Application of image processing, computer vision, and artificial intelligence in the categorization of low-quality mango problem. The study's objective is to develop a method for categorizing mangoes according to their color, volume, size, shape, and fruit density. Artificial intelligence is included into the image processing-based categorization system, including the usage of CCD cameras, C programming, computer vision, and artificial neural networks.

The system processes the split layer from the image of the mango that was acquired in order to calculate the mass, volume, and fault on the mango fruit's surface. To assess the quality of mangoes for export as well as local or recycled mangoes, pay particular attention to the density of mangoes in relation to their maturity and sweetness as well as the percentage of mango flaws.

2.1.4 Classification and grading of harvested mangoes using convolutional neural network

Iqbal and Hakim (2022) Mango (Mangifera Indica L., Anacardiaceae) is a climatic fruit with a short shelf life. Every year, a substantial amount of fruit

is wasted due to the time-consuming human grading and classification procedure. There is a need to replace traditional agricultural methods with automation technologies. This study discusses a deep learning-based approach for automatically classifying and grading eight harvested mango cultivars based on quality characteristics such as color, size, shape, and texture. Five data augmentation methods were used: image rotation, translation, zooming, shearing, and horizontal flipping. We used enhanced data to analyze three 3-layer Convolutional Neural Network (CNN) architectures: VGG16, ResNet152, and Inception v3. Using the Inception v3 CNN architecture, the proposed technique obtained 99.2% classification accuracy and 96.7% grading accuracy.

2.1.5 Mango Fruit Sortation System using Neural Network and Computer Vision

Yossy et al. (2017), Mango comes in a variety of colors and sizes, which indicate its maturity stage. When it comes to selecting a mango with a decent maturity level, growers are frequently puzzled. Mango producers often still utilize manual methods to determine mango maturity, despite the fact that human labor is frequently imprecise and inconsistent. The discrepancy is caused by each person's unique perspectives. Based on these issues, the importance of a machine sorting system in agriculture is

recognized. Therefore, the sorting method for mangoes will be the subject of investigation. Among the various varieties of mango are "Harum Manis," "Apple," "Gincu," and others. Mango "Gincu" will be the type of mango tested in this study due to its good color distribution. Developing a system that can distinguish between ripe and unripe mangos is the aim of the project. The research methodology is broken down into several steps: problem identification, algorithm development, implementation, and evaluation.

The C programming language, computer vision, and artificial neural networks (ANNs) are used in the system's construction to determine if a mango is ripe or not. This study's results will be contrasted with those of related studies. The technology can distinguish between ripe and unripe mangoes with 94% accuracy, according to the research's final outcome.

2.2 LOCAL LITERATURE AND STUDIES

This section contains local works of literature and studies that researchers used to gather knowledge and ideas for their thesis.

2.2.1 Deep learning-based embedded system for carabao mango (Mangifera indica L.) sorting

Liwag et al. (2019), This study presents the design and implementation of an embedded system for 'Carabao' or Philippine mango sorting that employs deep learning algorithms. In particular, the suggested method

accepts as input a top view image of the mango, which is then turned over to analyze all sides. The input photos were processed by the Single Shot MultiBox Detector (SSD) MobileNet for mango identification and the Multi-Task Learning Convolutional Neural Network (MTL-CNN) for classification/sorting ripeness and basic quality, both of which ran on an embedded computer. Raspberry Pi 3.

The dataset of 2800 mango photos from around 270 different fruits was annotated for fundamental quality (defective or good) and ripeness (green, semi-ripe, or ripe). The mango identification findings had a total precision score of 0.92 and a mean average precision (mAP) of more than 0.8 at the last stage. The accuracy of basic quality classification was 0.98 and 0.92, respectively, for faulty and high quality, while the ripeness classifications for green, ripe, and semi-ripe were 1.0, 1.0, and 0.91. Overall, the results demonstrated the feasibility of our proposed embedded system for image based Carabao mango sorting using deep learning techniques.

2.2.2 PhilMech-made mango sorting machine expected to reduce production errors and optimize production process

Mendez (2024), The Philippine Center for Postharvest Development and Mechanization (PhilMech) has successfully created a mango sorting machine that allows farmers to reduce production costs while increasing product value. The PhilMech automated mango sorting machine sorts and

categorizes green mango fruit using a computer vision system. The system can detect outward flaws, weight, and size. It operates by feeding mangoes into the system via a conveyor belt, which then passes through an image chamber before being sorted directly into classification bins. The machine reduces the labor needs from 20 to two personnel. The equipment sorted and graded mango fruits with 94.44% accuracy and precision, meeting international export criteria. It can also process 720 to 800 mangoes each hour. PhilMech anticipates that the sorting machine will be offered to farmers at a reasonable cost.

Compared to similar imported items that can cost up to P1 million, constructing a PhilMech mango sorting machine costs roughly P168,000. Tackling the concern of unemployment due to the automation of industries, lead developer Engineer Arlene Joaquin expresses that the Automated Mango Sorting Machine can be seen as an opportunity rather than a threat. She shared that among the concerns of some mango farms is the lack of manpower especially during peak harvest season. “Ang isa pong problema sa industry ay yung kapag nagsabay-sabay yung harvest, wala pong makuhang tao. And, [the Mango Sorting Machine] is a very good intervention kasi kumukuha pa po sila ng mga laborers sa neighbotowns,” said Engr. Joaquin.The PhilMech expectsto develop the machine further to cater to export-intended mangoes and other products. “Next year, naka-

programa itong subukan in the export of mangoes. So, exporters po ang titingin nito based on actual capacity and also for other circular vegetables," said Engr. Joaquin.

2.2.3 Determining 'Carabao' Mango Ripeness Stages Using Three Image Processing Algorithms

Manliguez (2019), Mangoes that have been harvested are often manually graded or sorted. This procedure is arduous, time-consuming, incorrect, and error-prone. Human inspection is highly subjective, and circumstances such as visual stress and weariness can lead to variations in judgment. The use of a chroma meter is reliable, although the equipment is costly. This study investigated the use of three digital image processing methods to determine harvested 'Carabao' mango ripeness stages. Canny edge detection, Sobel edge detection, and Laplacian of Gaussian detection techniques were utilized to extract a mango image from its original image.

The RGB values of detected images were transformed to L*a*b* color values, which were utilized to determine the ripeness level of mangoes based on a standard derived from 'Carabao' mango data. The standard was developed using the mango peel color index scale from the University of the Philippines Los Baños Postharvest Horticulture Training and Research Center (PHTRC). The overall accuracy of the algorithms' performance was 80.5% for the neural network-based Canny edge detection algorithm and

L*a*b* color extraction; 63.88% for the Sobel edge detection algorithm and L*a*b* color extraction using MATLAB software's rgb2lab function; and 17.33% for the Laplacian of Gaussian detection and L*a*b* color extraction using OpenCV. Overall, the implementation of Canny edge detection algorithm for image processing and L*a*b* color extraction using neural networks performed best among the algorithms used in classifying 'Carabao' mango ripeness stages. To enhance algorithm performance, optimize sample image quality by adjusting light, exposure, and camera settings. Use more chroma meter points on the 'Carabao' mango to achieve a better color average.

2.2.4 Automatic Mango Fruit Classifier Using Image Processing Through Pixel-Based Calculation, Correlation and Logic System

Lamsen (2021), Automated vision-based technologies are being employed in agriculture and food industries to improve product quality. Identifying mangos based on quality leads to increased pay for industry workers. Manual sorting presents challenges in producing consistent and accurate results. This article discusses an autonomous mango fruit classification system using visual technologies. This project aimed to create an autonomous mango-fruit sorting machine utilizing several image processing technologies. This study aimed to categorize and sort mango fruit samples based on quality. The study utilized new algorithms, processes,

methodologies, and software to extract physical attributes (size, color, and spots) and create a new product sorting approach that could benefit the agriculture industry. The project aimed to simplify product grading and classification technologies. Experiments were conducted to ensure system accuracy.

The vision system automates mango fruit classification and sorting, eliminating the need for manual inspection. To speed up the inspection process, maintain uniformity, and get accurate results, a system that processes images using several approaches was deployed. The extracted qualities of the fruits were blended utilizing program codes in the software. The combined qualities were rated using an established criterion. In addition, the output was represented by a graphical user interface and a voice prompt. The system had an accuracy rate of 93.33%.

2.2.5 DigiMango: A Digital Postharvest Evaluation Tool on Mango Fruit

Simbajon et al. (2020), The Carabao kind of mango, which is the most extensively farmed and dominates the export market, is one of the most significant fruits in the Philippines. Unfortunately, illnesses and insect pests have reduced the amount of Carabao mangoes produced for export, which has led to severe postharvest degradation. Among these illnesses, anthracnose is the most prevalent. A smartphone software called DigiMango assesses the degree of anthracnose in Carabao mangoes after harvest. The

application provides the ability to rate diseases and objectively assess the growth of lesions that resemble spots on the mango's surface. The mangoes used in the planning and testing were already pre-evaluated, and the illnesses were pre-identified, because this application was designed to be utilized in a laboratory.

The only goal of the application is to provide the researchers convenience and objective rating assessments. Using a mix of morphological transformation, contour approximation, smart edge recognition, and thresholding algorithm, the program was able to map the lesions by taking pictures of the mango from all four sides using the smartphone's camera. The study has demonstrated that using the Digi Mango application is appropriate and favorably connected with the experts' assessment after a comprehensive review of the program. Any variation from the researchers' hedonic scales is not statistically significant.

2.2.6 D-IoT-Box: An Automated In-Kind Donation Box and Management System with Image Processing for Rizal Technological University - Pasig Donation Drives

.Dancalan et al. (2023) introduced an automated donation box and management system named "D-IoT-Box" designed for Rizal Technological University's Pasig Campus. Donation Drives. The system combines hardware components with a web application to automate the sorting and

counting of donated items. It uses a single-board computer (Raspberry Pi), a microcontroller (Arduino), a Raspberry Pi camera, sensors, and motors for this purpose. The system uses a three-stage detection process: first, AI-based object detection with a camera identifies donated items; second, capacitive and inductive proximity sensors validate the AI's accuracy by confirming the presence of metal or non-metal on item packaging; and third, weight and ultrasonic sensors detect empty items and their presence. An infrared sensor is used to validate items' entry into the container. The system places empty and untrained in-kind objects in a designated container, while identified items are logged in the database. The D-IoT-Box comes with a user-friendly online application that provides real-time information and category breakdowns. Administrators can use this program to monitor the system, accessing critical data such as daily donation counts, popular items, and previous drive success, making it easier to oversee and manage donations. Thonny IDE, the LabelImg tool, and TensorFlow Lite all contribute significantly to the software development process. The LabelImg program is used during object detection training to annotate photos by generating bounding boxes and labeling them with dry products, canned foods, or hygiene. TensorFlow Lite is used to train a collection of pictures captured with the Raspberry Pi camera and annotated with LabelImg. This trained dataset is built within the Raspberry Pi single-board computer, and

Python programming enables the Raspberry Pi camera to be connected and trained in-kind products to be identified on the conveyor belt. Furthermore, Python is utilized to transfer data from detected things to the Arduino Uno.

2.2.7 Philippine National Standard PNS/BAFPS 13:2004

According to BAFPS (2004), Bureau of Agriculture and Fisheries Standards the mango fruit must be classified according to their appearance, quality and conditions first is extra class, this mango should be superior class it must be mature, clean, well-formed and without associated defects such as insects, diseases next is class I, the mango in this class is good quality and also has the characteristic of being smooth well-formed and without defects such as disease and insect bite and the next class is class II this mango is not qualify for inclusion in the higher classes but satisfy the requirement of class II mangoes must be mature, fairly clean, well- trimmed, and well-formed and without insect infestation, in terms of weight the extra class: five percent by number or weight of the fruit in any lot shall fail to meet the requirements of the class and shall conform to the requirements of class 1. Class I: ten percent by count or weight is allowed for off-sized items, including not more than 1% by count for other defects shall fail to meet the requirements but shall conform to the requirements of the next lower grade. Class II: ten percent by count or weight is allowed for off-sized items, including not more than 2% by count for other defects that shall fail to meet

the requirements.

Table 2.1 Stages of ripeness of carabao mango fruits

Stage of ripeness	Peel color	Flesh color
Unripe	Completely light green	Yellowish white or light yellow green
Ripe	80-100% percent yellow ('carabao')	Middle area yellow for 'carabao'
Decay	Visibility of dark spots,	Internal dark spot

Table 2.1 Display the understanding of the ripening stage of the carabao mango. When the mango is unripe, it is mostly green. As the fruit ripens, the green color changes to yellow. While a ripe Carabao mango has a golden yellow skin with hints of red or orange depending on the mango's exposure to sunlight, decay in Carabao mangoes refers to the process by which the fruit begins to spoil, deteriorate, or rot as a result of various factors such as improper handling, over-ripening, or exposure to microorganisms.

Table 2.2 Size classification of carabao mango fruits

Size	Weight (g)
Large	A large carabao mango weighs between 300 and 349 grams.
Medium	A medium carabao mango weighs between 250 and 299 grams.
Small	A small Carabao mango weighs between 200 and 249 grams,

Table 2.2 displays the understanding in weight classifications of carabao mangoes. it is a crucial aspect in grading mangoes based on their categories during the sorting process, the weight category of carabao mango are extra big, large, medium, small and super small.

2.3 Synthesis of the Related Literature

Table 2.3 illustrates the differences of the system and studies related to Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes.

Table 2.3 Synthesis of the Related Literature

System Function	Related Literature					
	System					
	System A	System B	System C	System D	System E	System F
Vision based Quality Detection vision systems are able to recognize surface imperfections like damage or discoloration,	✓	✓	✓	✓	✓	✓
Color Processing system The crops are photographed in detail as they go along a conveyor belt by high-resolution cameras installed on color sorting devices.	✓	x	x	✓	✓	✓
Sorting image Processing system These algorithms have the ability to precisely detect flaws and deviations, which improves grading decisions.	x	✓	✓	✓	✓	✓
Weight Natural frequency system It use sensors to detect changes in frequency induced by weight differences. The natural frequency of these sensors can be adjusted to ensure precise results.	✓	x	✓	✓	✓	✓

AI convolutional Neural networks Neural Networks are a strong tool in artificial intelligence and machine learning, especially for jobs that require visual data.	x	✓	✓	✓	✓	✓
Automated Clustering System The major purpose of automated clustering systems is to evaluate mangoes based on size, color, maturity, and defects.	✓	✓	✓	x	✓	✓

Table 2.3 evaluates the proposed project to other research. All of the systems listed above appear to provide at least part of the elements necessary for Innovative Artificial Intelligence-Based Fruit Quality Detection for Carabao Mangoes; nevertheless, there are some differences in the specific functions that both systems provide.

Advancement in artificial intelligence for on-farm fruit sorting and transportation

major goal of this literature review is to offer an overview, present a critical analysis, and highlight the problems and prospects of AI applications for on-farm sorting and transportation.

Machine Vision Based Techniques for Automatic Mango Fruit Sorting and Grading Based on Maturity Level and Size

This literature discusses an automatic electronic vision-based system for sorting and grading fruits such as mango (Mangifera indica L.) depending

on ripeness level and size. The implementation of automatic vision-based system, aiming to replace manual-based techniques for sorting and grading of fruit.

Mango Classification System Based on Machine Vision and Artificial Intelligence

The literature examined the use of image processing technologies, computer vision, and artificial intelligence to address the problem of mango categorization or low quality. The study's purpose is to develop a classification system for mangoes based on color, volume, size, shape, and fruit density.

Mango Sorting Mechanical System Uses Machine Vision and Artificial Intelligence

The study's purpose is to develop a classification system for mangoes based on color, volume, size, shape, and fruit density. The image processing-based categorization system integrates artificial intelligence, such as CCD cameras, C language programming, computer vision, and artificial neural networks. The system uses the collected mango picture and the split layer to calculate the mass, volume, and fault on the mango fruit surface.

Mango Fruit Sortation System using Neural Network and Computer Vision

The project aims to develop a system that can distinguish between ripe and unripe mangoes. This research was conducted in a series of steps, including issue identification, algorithm creation, implementation, and assessment. The system is built with C, Computer Vision, and ANN (Artificial Neural Network) to recognize the color of ripe or unripe mangoes.

MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting

This article focused on the characteristics of a good quality mango. According to the Bureau of Agriculture and Fisheries Standards, mango fruits must be classed based on their look, quality, and circumstances.

CHAPTER III
RESEARCH METHODOLOGY

This chapter presents and discusses the research methods used in the development of the MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting

3.1 Research Instruments

The researchers used an experimental method to analyze and interpret the data related to the developed system, aiming to determine its performance and accuracy based on set standards. In addition, they applied the Weighted Average Formula as a statistical method to calculate the weighted mean for each criterion and to assess the overall effectiveness of the system..

3.2 Descriptions of Respondents

The researchers selected a group of respondents to evaluate the functionalities of the design project. the population of interest is the local community of Cogeo Public Market in antipolo and the selected respondents are distributors, local vendors, and mango merchant . The participants in the study were people with experience in selling mangoes, and the proponents sought permission before conducting the questions. The proponents also ensured that the data and privacy of the participants were in strict custody. The participants agreed, and the proponents gave a brief explanation about the study.

The table below shows the frequency and percentage of the respondents who participated in the research.

Table 3.1: Frequency and Percentage of Respondents

Respondents	Frequency (f)	Percentage (%)
Distributor	2	20%
Vendor	3	30%
Mango merchant	5	50%
Total	10	100%

Table 3.1 presents that 50% of the respondents were mango merchant from Cogeo Public Market in antipolo, while 30% were mango vendor and the remaining 20% were are distributor. The respondents evaluated the MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting based on the functionality and reliability.

3.3 Populations of the Study

The researcher utilized convenience sampling to select the participants for the study, based on their availability and willingness to participate. The target population for the study consists of the vendors, distributor, and mango merchant. The total population of the study comprised a total of thirty (10) respondents. Five (5) of the total population were mango merchant, three (3) were vendor, and five (2) is distributor at Cogeo Public Market in Antipolo.

3.4 Online Research

It enables proponents to demonstrate their enthusiasm for the System improvement, gaining new knowledge, improving problem-solving abilities, and challenging individuals in novel ways are all goals. Leave a product of ideas that represent the proof of interests and studies, and potentially, a genuine addition to knowledge, with a self-initiated research project. The online respondents are mango sellers who give us an idea of market standard quality for carabao mango.

3.5 Questionnaire

A set of studied questions or research that is posed to respondents in order to elicit certain information. A questionnaire was employed by the researcher as a means of data collection. This tool was used to gather data regarding respondents' assessment. The participants' answers were interpreted using a 5-point Likert scale based on ISO 25010. The Likert scale had a sequence of statements, each with its own scale ranging from 5 to 1. A rating of 5 indicated the highest or positive response, while a rating of 1 indicated the lowest or negative response. The scale's middle point, 3, denoted a neutral response.

The following is the five-level Likert scale which used to interpret the data gathered:

Table 3.2: Scale Range

Scale	Numerical Values	Verbal Interpretation
5	4. 20 – 5.00	Strongly Agree
4	3.40 – 4.19	Agree
3	2.60 – 3.39	Neutral
2	1.80 – 2.59	Disagree
1	1.00 – 1.79	Strongly Disagree

The 5-point likert scale to interpret the responses of the participants. The likert scale contained a series of statements with an associated scale, ranging from 1 to 5. A rating of 1 represented the lowest or negative response, while a rating of 5 represented the highest or positive response. The center point of the scale, 3, represented a neutral response.

Validation of instrument

The survey questions for data collection were examined by the researchers in consultation with the thesis adviser in order to identify potential errors in the content and to confirm the instrument's validity and reliability. During the construction of the interview, survey, and questionnaire, the researchers made necessary changes and included all recommendations in

the final edition. They obtained permission from the distributor, seller, and customer before distributing the survey to the respondents.

3.6 Locale of the Study

The study will be conducted at the Cogeo Public Market in Antipolo. The hardware and system will be deployed at the researchers' residence, which is located nearby. The researcher aims to test and evaluate the accuracy of the study, with the help of the study advisors, students can also gain more knowledge and ideas that can improve the study. The researcher chose a place also based on the research questions. The right research locale is an essential part of the research process. to ensure the success of the research project.

3.7 Research Design

The researchers used the agile model because it provides several benefits, one of which is that it focuses on continuous improvement and testing, which results in superior quality outcomes, the agile model allows for greater flexibility and the ability to respond to changes quickly, which reduces the risk of project failure; and finally, it can be used to improve communication among researchers, which leads to improved system outcomes.

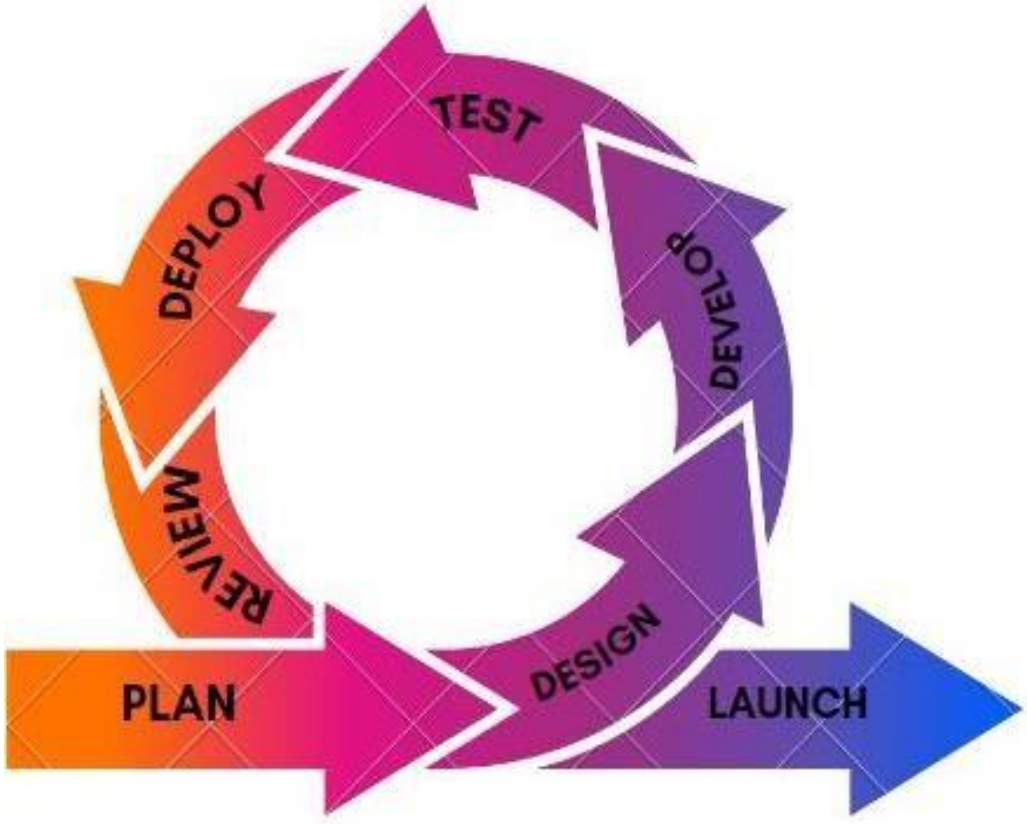


Figure 3.1 Agile Model

3.8 Requirement Analysis

In order to determine the flow of the existing system that is necessary, proponents examine the software design to ensure that it is well specified and planned. Proponents also gather information from an interview with the mango farmers, vendors, and distributors and analyze the request that has been made. A system that is dependable and appropriate for the community is what detailed thinking aims to create.

Requirements: The researchers have compiled and examined all of the

project's specifications, including choosing the right versions of components like Arduinos. The researchers also collect data by looking into the best conveyor while utilizing an Uno microcontroller and a Raspberry Pi 4B. A mobile application is created for data display, and the researchers study the carabao mango quality that the system will detect and sort, taking into consideration the constraints and limitations of the system and requiring training for detection. This helps them determine the specific type of sensors that will be used, the motors that will be needed, and the conveyor belt that the carabao mango will be on.

Planning - The researchers plan how the project will be developed. This comprises the objectives, scope, and limitations. Project objectives, design, and requirements a raspberry pi camera with AI detection will be used to identify the carabao mangoes, as well as a weight sensor to determine the weight of the carabao mango, an ultrasonic sensor to detect the presence of the carabao mangoes. The researchers will develop container for decaying mango. Furthermore, the researchers will develop a risk management plan to mitigate any potential dangers to the project. This involves hardware and software failures, as well as budget limits. To minimize the risks and their impact on the project and budget, the researchers will create contingency plans a research plan is critical for leading your study, identifying research aims, structuring the research process, obtaining financing and support,

remaining flexible, influencing decision-making and policy, pushing technical improvements, and improving skills.

System Design - The system software features had to be friendly and easy to traverse by any user, the proponents researched the goal of the system and make it more Graphic user Interface (GUI) pleasant, and the system inputs had to be protected and reliable. As a result, the system design is complete. This system design aids in the definition of hardware and system requirements as part of the overall system design process.

System development: The researchers are working on IDE development for Arduino and Raspberry Pi, and the team is working on several stages, such as coding and testing, to ensure a successful end. They also did hardware development: The researchers are designing hardware based on the 3D design.

Testing - Once each unit's testing has commenced, all of the units generated for the implementation phase are combined into a system. The system is reviewed and tested to find vulnerabilities and problems.

Deployment - The device is prepared for deployment to the researchers' home close to the market after testing is over, allowing mango vendors to sort their mangoes.

Implementation - When the system requests information from the user, the underlying routines quickly insert it into the database. The system developed

programs with underlying codes based on process inputs. The technique of analyzing each unit for usability is known as unit testing.

Review: The researchers have reviewed all of the project's specifications, including the components. The researchers also did code review; they evaluated code quality, optimized performance, and ensured compliance with coding standards. They also do content review, assessing written or visual content for accuracy, relevance, and alignment with project goals…

Launch the researchers complete development, fix bugs, and make sure the final prototype satisfies quality requirements. Then it was made accessible to users. After the product is launched, feedback from users is gathered to improve it in future sprints.

Maintenance - Proponents are aware of the possibility of unexpected issues; as tested, they may encounter hardware failure due to dust and environmental changes, so it must be put in a cover glass that can protect it from disrepair. The proponents provide assistance regarding this issue. The system is also prone to hackers; if the system begins to monopolize by unknown programs, the proponents will issue a reformat assistance so that the data can't be stolen.

3.9 Unit Testing

The researchers conduct a test on the components to identify if the components are working.

Table 3.3 Component Testing

Component Testing	Expected Values	Test 1	Test 2	Test 3	Remarks
Raspberry Pi 4 B	Boot time: 60s	60s	60s	60s	Woking
Arduino nano microcontroller	Boot time: 5s	5s	5s	5s	Woking
Arduino Uno microcontroller	Boot time: 5s	5s	5s	5s	Woking
Raspberry Pi Camera	Capture speed: 0.4 fps	0.3fps	0.4 fps	0.4 fps	Woking
Servo Motor	Angle: 180°	Angle: 180°	Angle: 180°	Angle: 180°	Woking
Stepper Motor	Angle: 360°	Angle: 360°	Angle: 360°	Angle: 360°	Woking
Continous servo motor	Angle: 360°	Angle: 360°	Angle: 360°	Angle: 360°	Woking
Straight Bar Load Cell / Weight Sensor	Output: Read all weight Data	Carabao Mango (Large) Output: Read the weight size	Carabao Mango (Medium) Output: Read the weight size	Carabao Mango (Small) Output: Read the weight size	Woking
Ultrasonic Sensor	ON	Whole Carabao Mango Output: Object Presence Detected	Whole Carabao Mango Output: Object Presence Detected	Whole Carabao Mango Output: Object Presence Detected	Working

Table 3.3 summarizes the testing for each component. The components examined included an ultrasonic sensor, a weight sensor, and additional components like servo motors. Testing of the Raspberry Pi 4, Arduino Uno microcontroller, and Raspberry Pi Camera shows full functionality.

3.10 System Testing

The researchers tested the system's ability to recognize the grade of carabao mangoes.

Table 3.4 Common Confidence Threshold Ranges in Object Detections

Confidence Threshold	Percent/Confidence Range	Description
Low Threshold	(40%-50%) or (0.4-0.5 confidence)	Increases detection rates but may result in more false positives
Moderate Threshold	(60%-70%) or (0.6-0.7 confidence)	Offers a balance between true positive detections and false positives.
High Threshold	(80%-99%) or (0.8-0.99 confidence)	Reduces false positives but may miss some true detections.

Table 3.4 shows the table indicates the common threshold ranges in Object Detection. A low threshold maximizes detection but increases errors,

a moderate threshold provides a balanced approach, and a high threshold ensures precision but may overlook some valid objects.

Table 3.5 Hardware Detection

Sensor Detection	Test 1 & Value	Test 2 & Value	Test 3 & Value	Expected Result	Remarks
Straight Bar Load Cell / Weight Sensor	Trained Carabao Mango (Large) Output: 1 Read the weight size	Trained Carabao Mango (Medium) Output: 1 Read the weight size	Trained Carabao Mango (Small) Output: 1 Read the weight size	Output: Read all sizes of Carabao mango.	The actual grams of the Carabao mango are detected and equal to the output of the weight sensor.
Ultrasonic Sensor	Carabao Mango Output: 1 Object Presence Detected	Carabao Mango Output: 1 Object Presence Detected	Carabao Mango Output: 1 Object Presence Detected	Output: Object Presence Detected	The Carabao mango presence is detected

Table 3.5 highlights the sensor detection tests. Before starting with system sorting, the weight sensor is checked to ascertain the weight of the carabao mangoes. The mango will proceed to camera detection in order to verify the quality, depending on the mangoes' color and appearance. the ultrasonic system is tested to see if the mango is being transported on a conveyor line and that will assess the type of container that is going to be available.

3.11 System Integration Test

The researchers test to see if hardware and software work together.an essential stage in the software development process that assesses how various modules of a software system interact to confirm they operate together without issues. It occurs after unit testing, in which single components are assessed, and before system testing and user acceptance testing.

Table 3.6 System Integration Test

Hardware and Software	Test or Tested object	Expected Result	Actual Result	Remarks (Pass or Fail)
Hardware Detection	Test if the Hardware detection can detect the trained Carabao Mangoes: • Ripe • Raw • Decay	The trained Carabao Mangoes are detected and the data is transmitted.	The system detected the Carabao Mangoes and data is transmitted to database.	PASS
Hardware Sorting	Test if the hardware can sort the trained Carabao Mangoes according to their category. Carabao Mangoes: • Ripe • Raw • Decay	The trained Carabao mangoes are sorted into their designated container.	The system sorts the trained Carabao mangoes into their designated container.	PASS

Database	Test if the data of detected and sorted Carabao mangoes are stored store in database. Carabao Mangoes: ● Ripe ● Raw ● Decay	The data of detected and sorted trained Carabao mangoes is stored	The data of detected Carabao mangoes is stored in database and retrieve successfully.	PASS
Mobile Application (Security)	Test if the mobile application login form has user validation and the data is secured.	The Mobile application is protected from unauthorized users and the data is secured.	The mobile application contains login form and the data is encrypted.	PASS
Mobile Application (Performance)	Test time of retrieving data in database and displaying on the Mobile application	The response time is within 1-5 seconds	The retrieving of data is within 2-3 second.	PASS

Table 3.6 depicts the integration of hardware and software to ensure that the components are properly integrated and work as expected. It performs a certain task, in this case, the identification and sorting of carabao mangoes. And transmitting information about these things to a database. The solution not only merges hardware and software, but also includes a mobile application that shows the device's acquired data. Researchers also believe that mobile application security is an important aspect of mobile app development and usage. With the increased reliance on mobile apps for a number of functions, including showing real-time data, Researchers also do

maintenance since proper maintenance is critical for the best performance, lifespan, and safety of the systems.

Figure 3.2 System Integration with Mobile Application

Figure 3.2 displays the testing of hardware detection, sorting, database, and mobile application, indicating the successful integration of all components for a full evaluation of the system's operation.

3.12 Statistical Treatment of Data

The following statistical methods were used to analyze and to interpret the results:

1. Percentage. This statistical treatment was used in the description of the samples and to show the differences of respondents.

Formula: $P = \frac{f}{n} * 100\%$

Where:

P = percentage

F = frequency

N = total number of respondents

2. General Weight Average: It was used for survey data interpretation and summarization.

Formula $\overline{X} = \frac{\sum WnXn}{\sum Wn}$

Or expended as:

$$\overline{X} = \frac{W_1+W_2+\cdots+Wn\ Xn}{W_1+W_2+\cdots+Wn}$$

Where:

$\overline{X}$ = the mean value of the set of given data.

Xi = individual ratings

Wi = corresponding weight for each observation.

n = number of ratings

CHAPTER IV

ANALYSIS PRESENTATION AND INTERPOLATION OF DATA

This chapter explains a new design project. This chapter covers the project overview, software and hardware requirements, system flow, technical specifications, system requirements, testing results, and respondent evaluation.

4.1 Project Overview

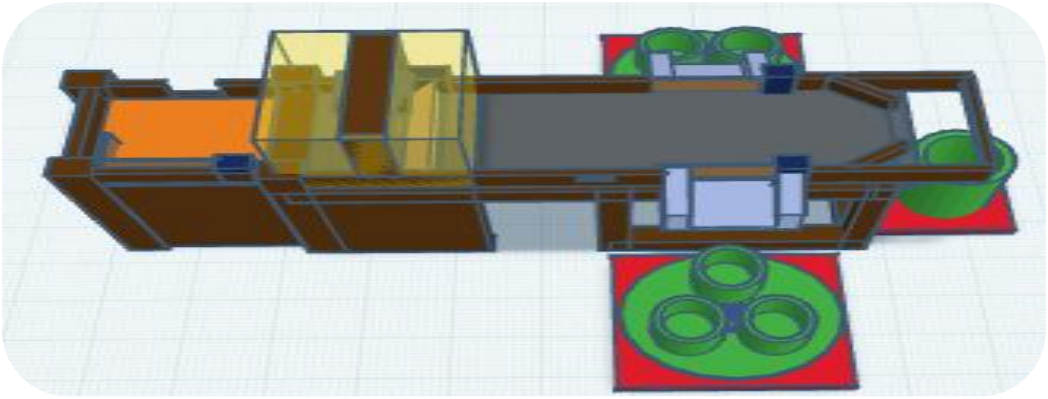
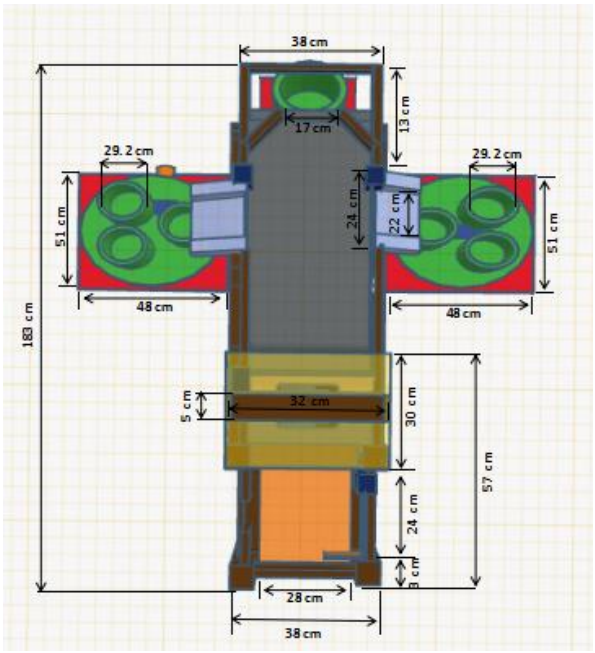


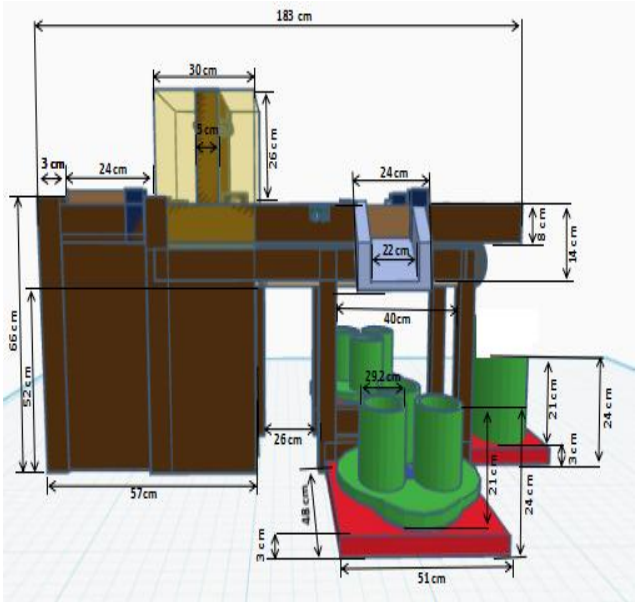
Figure 4.1 3D model of the Project

The project seeks to be useful in sorting carabao mangoes and determining their quality, and it was trained with the assistance of Rizal Technological University professors for guidance and consultation. The goal is to promote an effective method of identifying the quality of carabao mangoes, which will assist to minimize manpower and eliminate errors in sorting carabao mangoes. To ensure the success of this project, several hardware and software needs are considered and established through presentations.

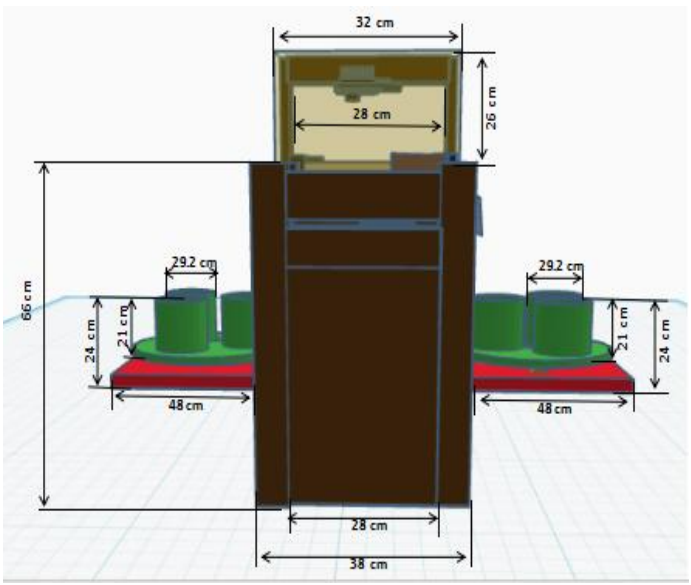
4.2 Design Layout



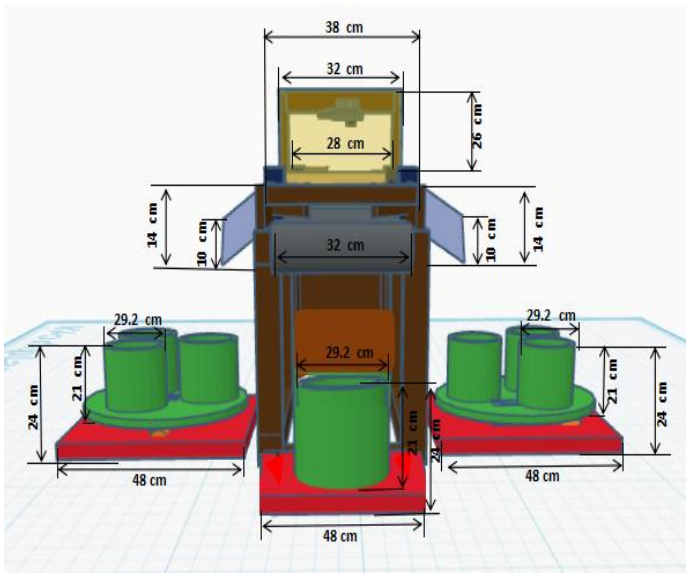
Top View



Side View



Back View



Front View

Figure 4.2 3D model with Dimension

Figure 4.2 depicts an overview of the project's 3D model design layout, including top, side, back, and front views. The researcher created the design

using TinkerCad modeling software. The layout is nearly same, and the researchers utilize different materials to complete the project; nevertheless, the box and container are not precisely the same in the pattern.

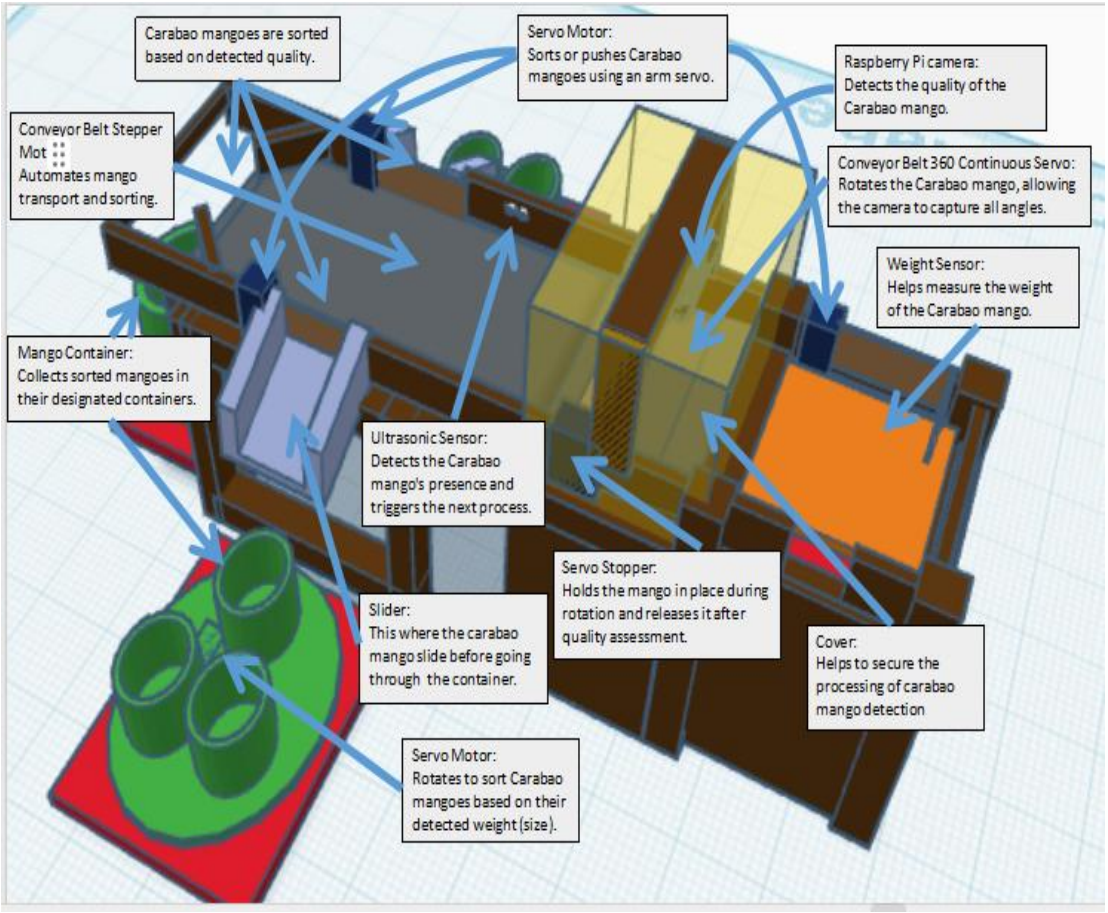


Figure 4.3 3D Model with Components Part

Figure 4.3 displays the major hardware components utilized in the Carabao Mango Quality Detection and Sorting system, emphasizing their functions and contributions to accurate and efficient sorting. It incorporates

a Raspberry Pi camera for detecting mangoes, servo motors for controlled movement, a conveyor belt system for transportation, and sensors for detecting, weighing, and classifying carabao mango.

Actual Design of the Proposed Research Study

In this figure shows the real configuration of the proposed project, including the hardware, physical look, and components. It also provides a clear and comprehensive perspective of the system design

Figure 4.4 Actual Design

Figure 4.4 presents the actual layout of the fully functional design project. The stages of system detection are working properly and capable of determining the, quantity, weight, and quality of carabao mangoes; it can

sort them and count their numbers. The counted result will be sent to the database and displayed on the mobile application in real time for monitoring purposes.

4.3 Software Requirements

The researchers have determined the software requirements for the project's development. This includes developing a mobile application for real-time monitoring of the number, quality, and weight size of carabao mangoes passing via the conveyor belt. Android Studio serves as the official Integrated Development Environment (IDE) for building Android apps. Figma is used to create user interfaces that may then be exported to Android Studio for development. TensorFlow was used to code and build AI carabao mango quality detection using the Raspberry Pi 4b, while the Arduino IDE was used to code the functionality of components such as servo motors, straight bar load cell weight sensors, Infrared sensors and Ultrasonic sensors.In addition, the mobile application has a login form, which is required for security and functioning, as well as a dashboard for data presentation. Dashboards are centralized systems that combine, organize, and show data in a visually appealing format.

TensorFlow is utilized to create AI carabao mangoes detection for the project, as well as to transmit picture datasets obtained by Raspberry Pi camera. TensorFlow's rich ecosystem of tools, modules, and resources

makes it easier to create and deploy AI-powered applications and YOLOv5 is used it is a computer vision model specifically intended for carabao mango quality identification tasks. Researchers also employed Robolfow, which provides a range of tools for computer vision applications, such as image annotation, datasets management, model training, and deployment, plus Google Colab Copilot a basic application that assists researchers with code jobs in Google Colab, helping them to complete code implementation.

4.4 Hardware Requirements

The researchers have determined the particular hardware components required to complete project development. They have assured that the selected hardware components meet the project requirements via thorough analysis and research, providing a solid basis for the system's execution and operation. The table below provides the specs that are being used to create the system.

Table 4.1 Device Descriptions

Device Name	Descriptions
Arduino Uno R3	The Arduino Uno R3 differs from its predecessors in that it uses the ATmega16U2 chip as a USB-to-serial converter rather than the FTDI chip. This enables more flexible programming and quicker communication.
Ultrasonic Sensor	Ultrasonic sensors are adaptable electronic devices that measure distance by producing high-frequency sound waves and analyzing the echoes that

	bounce off an object. They may detect distances without making physical contact with things, which reduces wear and tear.
Raspberry Pi 4 B	The Raspberry Pi 4 Model B provides desktop-level performance equivalent to entry-level x86 PCs, making it ideal for a wide range of applications, including education, media centers, and IoT projects. It enables dual-display output at resolutions of up to 4k.
Raspberry Pi Camera 3	The Camera Module 3 includes a 12-megapixel Sony IMX708 sensor for high-resolution still photos and video recording. It is compatible with all Raspberry Pi devices and offers both normal and wide-angle configurations.
Stepper motor	A stepper motor is an electric motor that moves in discrete steps, allowing for fine control of position, speed, and torque. This feature makes it excellent for applications that require precise positioning, such as 3D printers, CNC machines, and robots.
Servo MG995	Because of its strong performance and reasonable price, the MG995 servo motor is a well-liked option for a variety of robotics and remote control applications.it was one of the best because of its high torque, robustness, and simplicity in integrating with control systems,
Straight Bar Load Cell Weight Sensor	A straight bar load cell is typically made of a metal bar with strain gauges mounted in a Wheatstone bridge design. When a load is applied to the bar, it deforms slightly, resulting in a change in electrical resistance that can be measured and converted to a weight reading.
Black Conveyor Belt	Conveyor belts automate material movement, saving time and effort associated with physical handling. They enable the continuous flow of goods,

	reducing bottlenecks and speeding up production or order fulfillment procedures.
Bore Ball Bearing	Bore ball bearings serve an important function in decreasing friction and supporting loads in a variety of mechanical systems. Their design and characteristics make them appropriate for a wide range of applications in many industries.
Servo Shield	Servo shields enable users to easily connect several servos to an Arduino board by providing specialized circuitry for power management and control signals. This is especially beneficial in robotics and automation applications where several servos are required. A servo shield is an indispensable tool for anyone working with Arduino-based projects that require precise control of multiple servos.
Conveyor Roller	Conveyor rollers are critical components in conveyor systems that assist the flow of materials and goods. They play an important role in optimizing material handling processes across a wide range of industries. Their design modifications enable them to cater to unique operational needs, increasing efficiency and productivity in conveyor systems.
Driver Model: L298N 2A	The L298N Motor Driver Module is a powerful and adaptable motor driver that is generally used to operate DC motors and steppers. It makes use of the L298N dual H-bridge driver IC, which is appropriate for a variety of robotics and automation applications. The L298N module can control up to two DC motors or one stepper motor, with directional and speed control. It is designed to carry a maximum current of 2A per channel, allowing it to drive larger motors efficiently.

4.5 Process Flow Diagram

In this part, the researchers have created a process diagram to describe the system development process. A process diagram, also known as a process flow diagram (PFD), is a visual representation that displays every step necessary to accomplish a certain project process. It uses standardized symbols to explain and represent the flow of each phase, ensuring that essential procedures are performed to the same quality each time. Process diagrams are important tools for documenting, analyzing, and improving workflows.

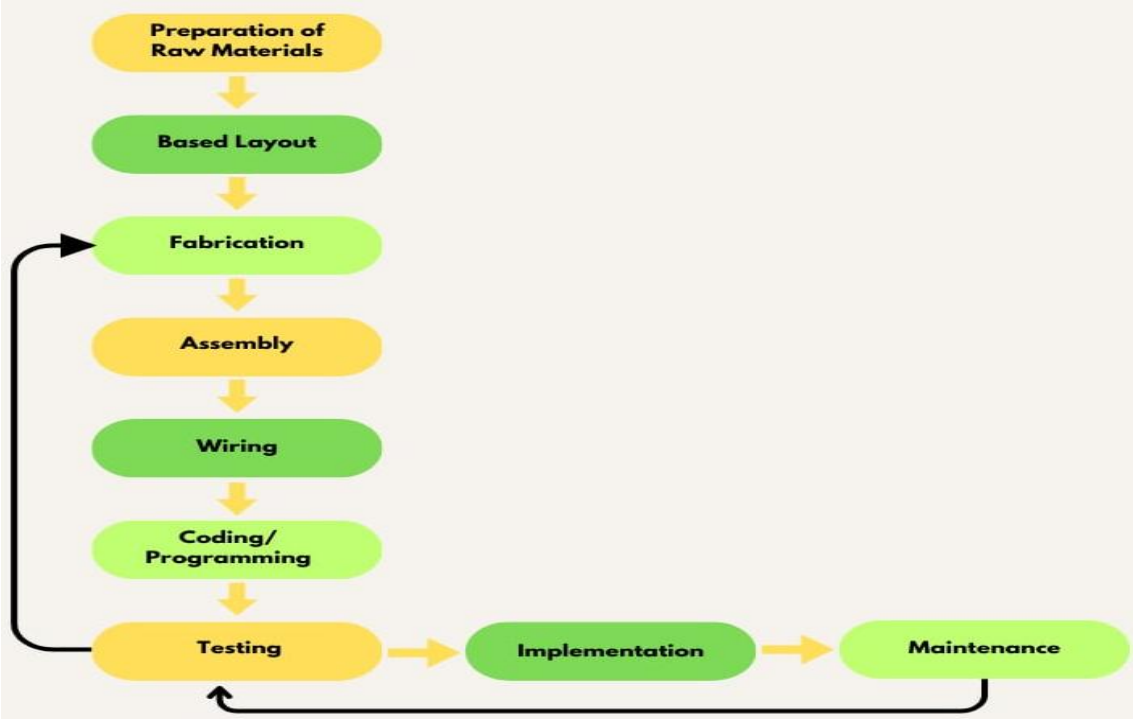


Figure 4.5 Process Flow Diagram

Figure 4.5 represents the step-by-step process of project design and development.

Preparation of Raw Materials - Gathering the supplies and equipment needed to construct the prototype was the focus of this phase. The proponents made certain that all necessary building supplies, such as plywood, hardwood, steel bolts, nuts, conveyor rollers, and conveyor beds, were on hand for construction. The Raspberry Pi, Arduino Uno, servo shield, stepper motors, servo motors, weight and ultrasonic sensors, and the Raspberry Pi camera were also ready as electrical components. This step made sure that all the resources were prepared before moving on to the following stages.

Based Layout - During this phase, researchers develop the project's plan and acquire the necessary resources, such as the Arduino Uno, Raspberry Pi, Raspberry Pi camera, sensors, conveyor belt, motors, and containers.

Fabrication - During this stage, the researchers construct the conveyor belt that acts as a platform for the carabao mangoes, sensor containers, other parts including motors, and Arduino Uno, Raspberry Pi, and a Raspi camera. creativity and woodworking fosters creativity and innovation by enabling researchers to design, build, and customize unique pieces, which provides a foundation for artistic expression and originality. The researchers use this combination of woodworking to provide a good foundation for design.

Assembly - Following the completion of the foundation, the researcher assembles and connects the motors, sensors, and other parts that make up the design prototype.

Wiring - During this step, the researchers connect all of the cables from the sensors and other components to the Arduino Uno microcontroller and Raspberry Pi 4. The significance of correctly connecting wires cannot be emphasized, as it is critical for safety, functionality, efficiency, equipment lifetime, and compliance with electrical standards and regulations.

Coding / Programming - During this phase, the researchers coded the functions of the components into the Raspberry Pi and Arduino Uno microcontroller. The programming allows the system to recognize carabao mangoes and save data to a database, which will then be presented on the mobile application.

Testing - The system was subjected to thorough testing to verify that all mechanical, electrical, and software components functioned cohesively as designed. Tests were conducted on the conveyor operation, sorting mechanism, sensor accuracy, and motor responsiveness to ensure reliable performance. The servo arm, responsible for transferring motion, was also evaluated its length and point of attachment directly influencing the range and speed of movement. Any identified issues were resolved through appropriate hardware or software modifications, ensuring the system

operated smoothly prior to final deployment.

Implementation - During this phase, the researchers prepare to deploy the device to the researchers' home close to the market allowing mango vendors to sort their mangoes.

Maintenance - During this phase, the researchers maintain the device and mobile application after deployment to guarantee that it continues to function properly and without faults. Regular maintenance is done to increase software product dependability and stability by discovering and correcting defects, reducing system failures, and improving the user experience. Researchers maintenance also improves software performance by fixing issues that influence speed, efficiency, and responsiveness, providing optimal results.

4.6 Block Diagram

The researchers create a block diagram of the proposed project in this stage to give a visual depiction of every aspect of the system and their connections.

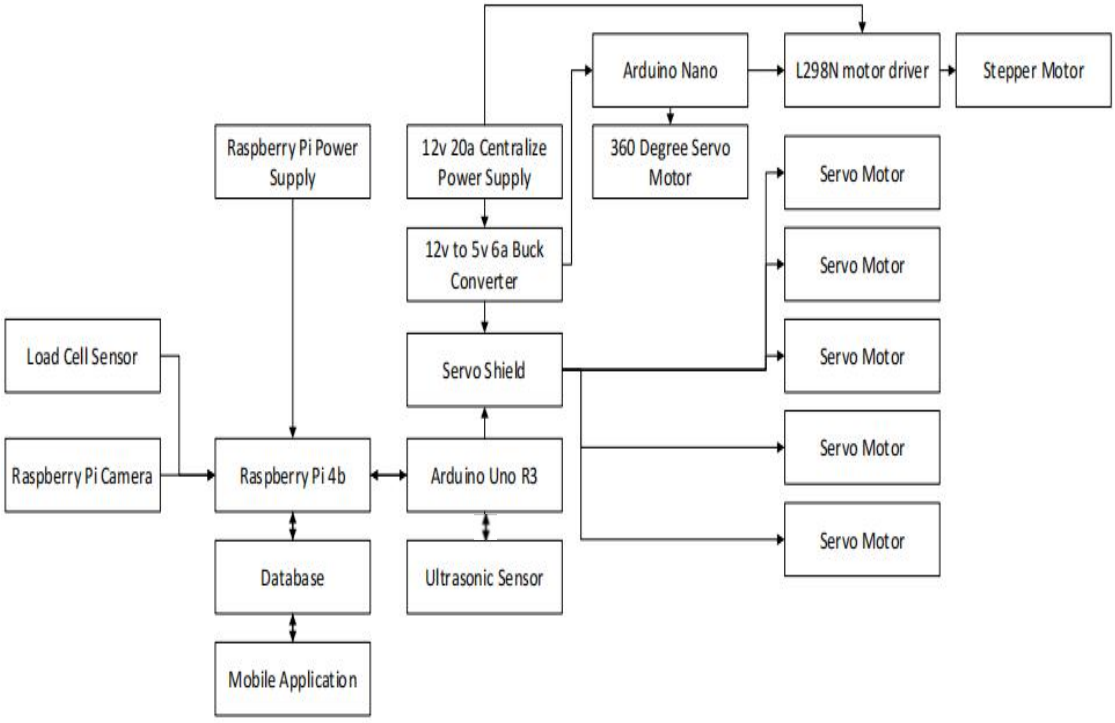


Figure 4.6 Block Diagram of the MangoQ

.Figure 4.6 presents the block diagram of the system, highlighting its two primary components: the Raspberry Pi 4 and the Arduino Uno microcontroller. The Arduino Uno is powered through a USB connection from the Raspberry Pi, while the Raspberry Pi 4 operates with a 5V power supply. These two devices are interconnected to facilitate two-way data communication. The system is equipped with multiple sensors, including an ultrasonic sensor, a straight bar load cell weight sensor, and a servo shield. All sensors and components are properly integrated. Additionally, the setup includes a servo motor powered by a 5V adapter and a DC motor that uses a 12V DC power adapter. A Raspberry Pi camera is also connected to the

Raspberry Pi 4 B, which is integrated with a database to store data collected during the detection process. This setup supports real-time monitoring through a mobile application.

4.7 Schematic Diagram

During this phase, researchers design a schematic structure of the proposed project to demonstrate detailed connections and interactions. A schematic diagram is important because it abstracts the complexity of an electrical circuit into a more digestible form by using standardized symbols to represent various components.

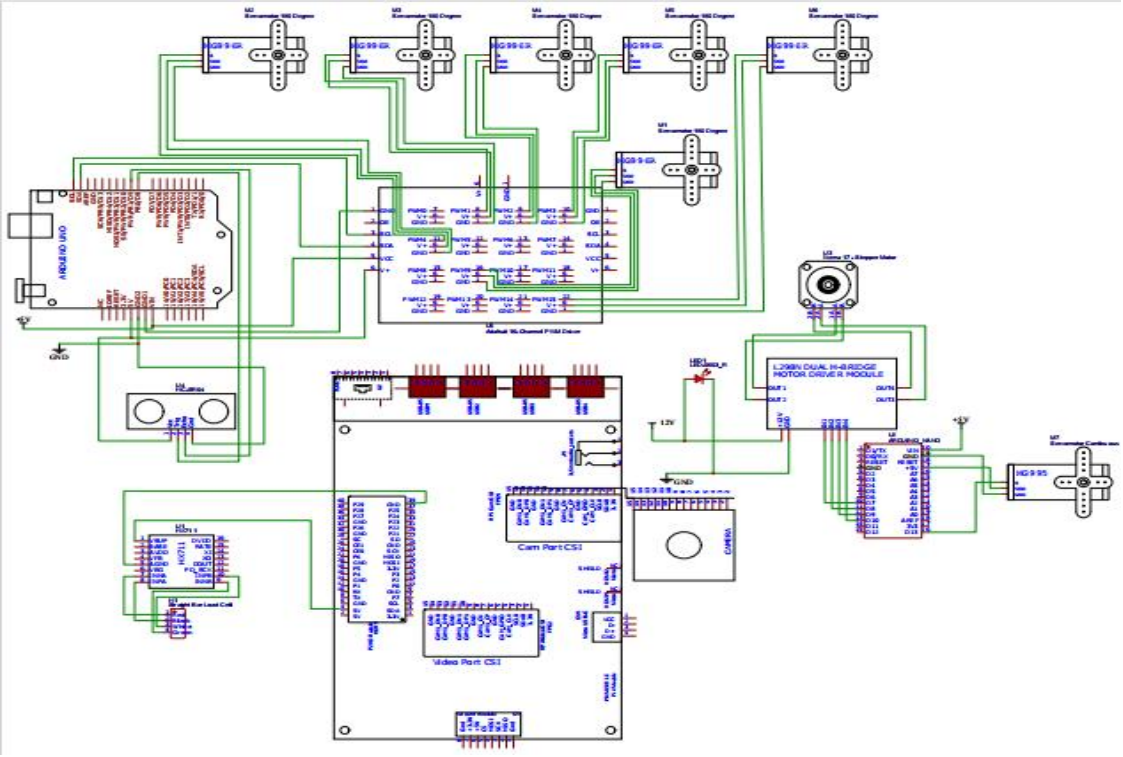


Figure 4.7 Schematic Diagram

Figure 4.7 presents a schematic design of the system. The system

consists of the, Arduino Uno, Raspberry Pi 4B, Raspberry Pi camera, and a variety of sensors, including ultrasonic, Straight bar load cell weight sensor. Includes a servo shield and motors . The servo shield is connected to the Arduino, along with sensors and other components, and a servo shield covers the servo motors. The sensors are connected to the Arduino Uno microcontroller, which performs the stage of system detection. The motor driver connects with the Arduino Uno motor . In addition, the Raspberry Pi camera is attached to the Raspberry Pi 4 B to enable trained AI quality recognition of carabao mangoes.

4.8 Flowchart

In this section, the researchers developed a flowchart to illustrate the proposed project workflow or processes. This visual representation outlines the various stages of the system, including the movement of inputs, outputs, procedures, and the actions taken at each step. Flowcharts assist researchers in comprehending, conveying, and enhancing processes by presenting them in a clear, visual format. They make complex concepts easier to grasp, improve communication, and support process optimization by clearly mapping out the necessary steps.

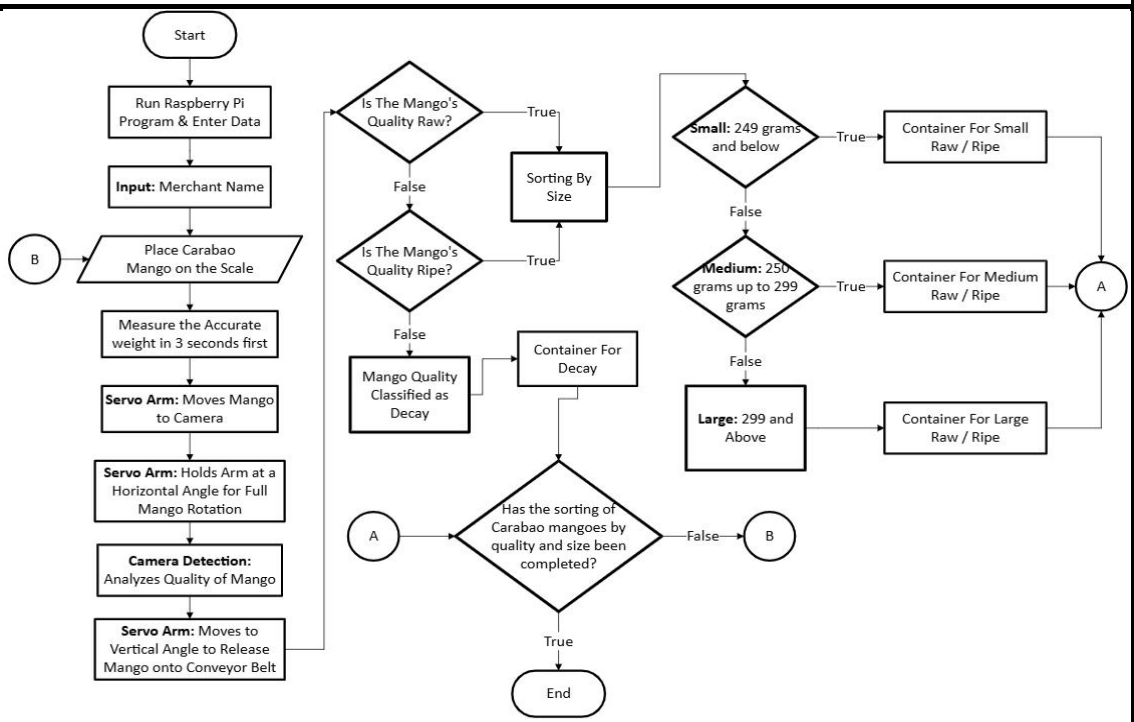


Figure 4.8 Flowchart

Figure 4.8 the system flowchart, which demonstrates the process flow of detecting, sorting, and storing the count of trained carabao mangoes, as well as separating decay in the designated container. Flowcharts serve an important role in improving knowledge of communication, analysis, documentation, and planning in a variety of situations, making them an invaluable tool for researchers studying problem solving, decision-making, and process optimization. The flowchart employs a variety of symbols to indicate distinct stages of the process, including a rectangle for process steps and diamonds for decision points. Arrows link the symbols to represent the flow of the procedure.

4.9 System Architecture

In this part, the researchers create a system architecture of Proposed project.

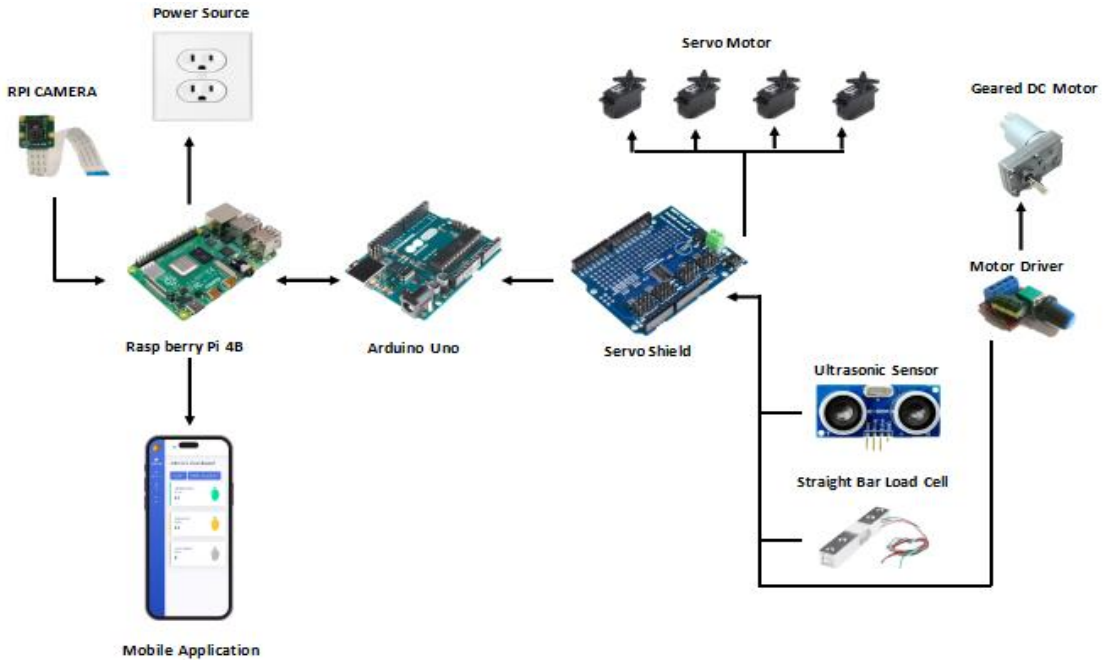


Figure 4.9 System Architecture

Figure 4.9 the design project's system architecture, including the connections between the components used in its creation. The Raspberry Pi camera communicates with the Raspberry Pi for AI object detection, while the Raspberry Pi 4 is powered by 5V and the Arduino Uno is powered by the Raspberry Pi via USB. The essentials sensors are linked to the Arduino Uno so that they can work. The Arduino Uno is linked to the servo shield, which connects servo motors to DC motors. Sensors, including ultrasonic and infrared sensors, are also attached.

4.10 AI Model

Researchers have utilized the YOLOv5 model, developed by Ultralytics, as a cutting-edge object detection algorithm commonly applied in computer vision tasks. In the context of AI-driven mango sorting systems, YOLOv5 has been employed to automate the classification and quality evaluation of Carabao mangoes. Taking advantage of its real-time detection capabilities, the system can effectively identify and sort mangoes based on key attributes such as ripeness, and visible defects.

Figure 4.10 AI Model

Figure 4.10 The YOLOv5 AI model is trained using a detailed dataset of Carabao mango images. Each image is annotated to mark the mangoes and may include labels for attributes such as ripeness and visible defects. During training, YOLOv5 learns to recognize distinct visual features such as shape, color, texture, and edges that help differentiate mangoes from the

background and other objects. Once the training is complete, the model can evaluate new images or video feeds to accurately detect mangoes, drawing bounding boxes around them. It also provides a confidence score and classifies each mango as ripe, unripe, or decayed. After classification, the system can group the mangoes into predefined categories data presented in mobile application and carry out sorting using servo motors and conveyor belt systems.

The researchers used ultralytics yolov5 model to detect an object. Ultralytics YOLOv5 is a highly popular and efficient object detection model based on the "You Only Look Once" (YOLO) architecture, specifically designed for realtime applications, YOLOv5 stands out due to its speed, ease of use, and practical accuracy. The model is designed to process entire images in a single forward pass, which allows it to quickly and accurately predict multiple object locations and class labels. It outputs bounding boxes, object classes, and confidence scores in a highly efficient manner, ensuring minimal delay during inference. Another major advantage is the ease of training on custom datasets.

4.11 Network Architecture

Shows how the proposed system would operate. It explains the functionality where the proposed system provides.

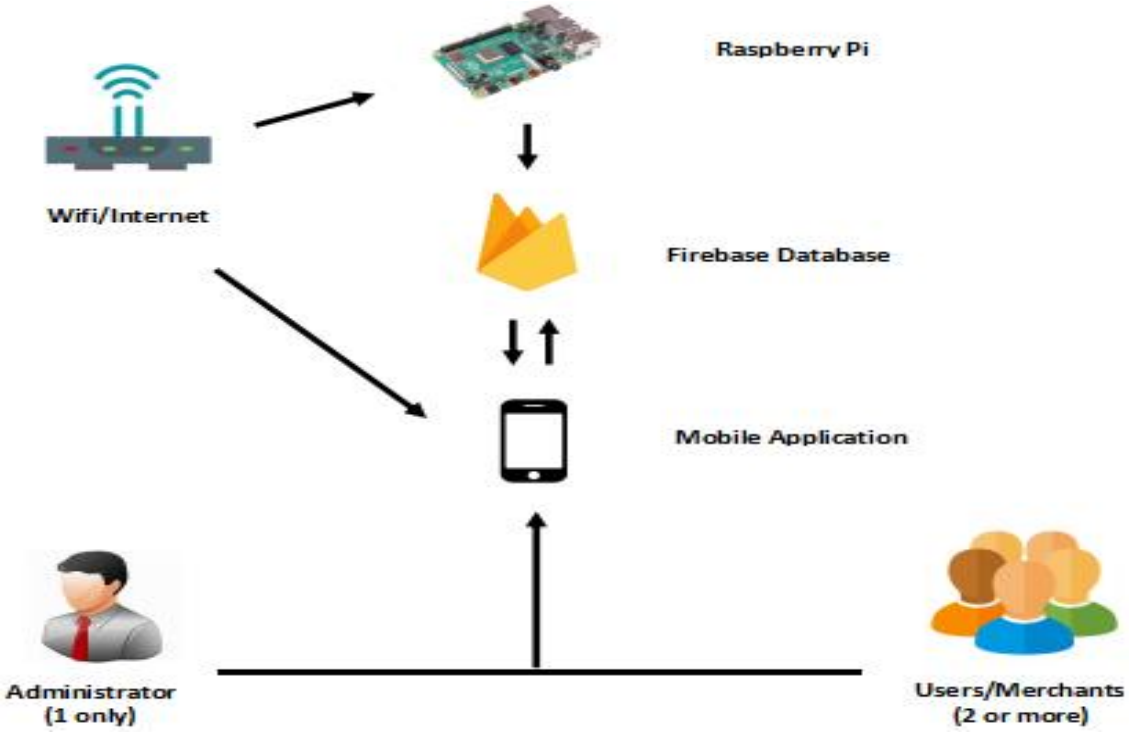


Figure 4.11 Network Architecture

Figure 4.11 shows the network architecture for the design project. It demonstrates how the Raspberry Pi 4 sends detected data from carabao mangoes to a database and provides real-time updates to the mobile application, that manage by administrator and viewed by users.

4.12 Concept of Operation

In this part, the researchers create an understanding of operation for the Proposed project. The Concept of Operations (ConOps), as defined in IEEE Standard 1362-1998, is a key artifact in systems and software engineering that provides a user-oriented view of a system and its intended operation. According to IEEE 1362-1998, the ConOps document articulates the envisioned system's operational characteristics in the context of real-world scenarios, organizational policies, and environmental conditions. It tells the system's story from the perspective of users, supporters, and those affected, promoting good communication and expectation alignment before detailed requirements analysis and design.

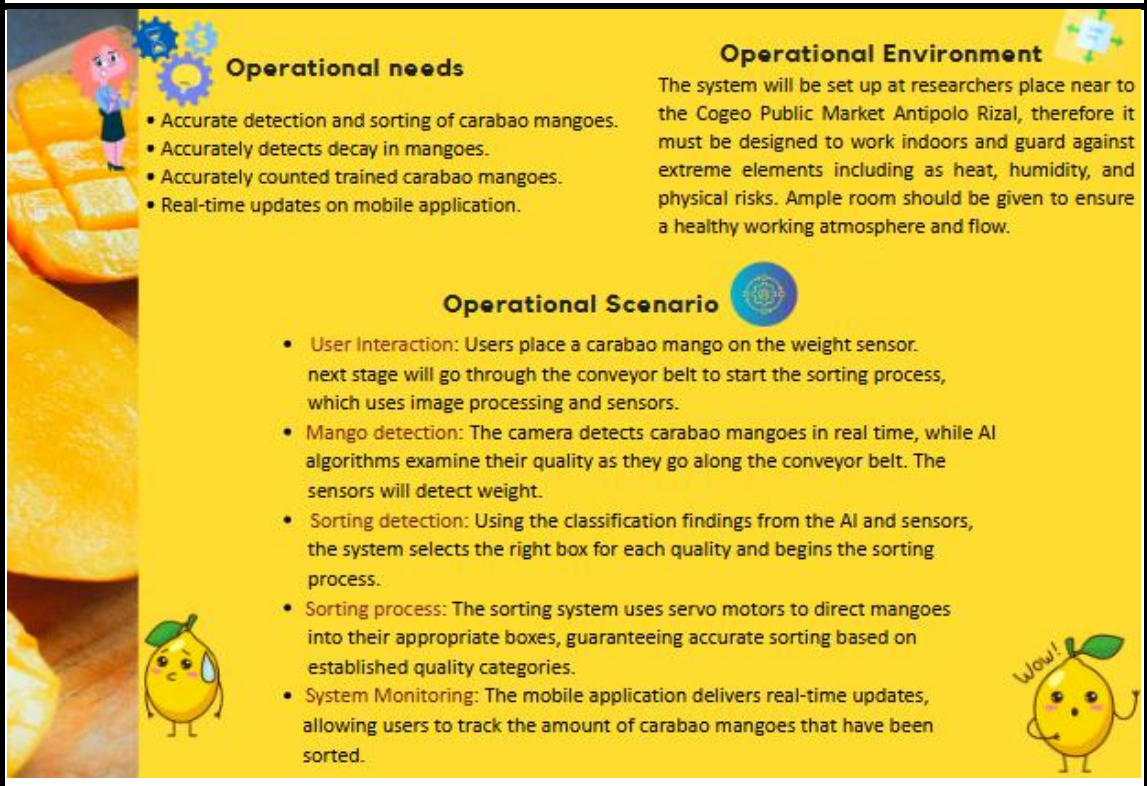


Figure 4.12 Concept of Operation

Figure 4.12 illustrates the design project's operational idea. The researchers create an overview of operations, including major components,, objectives, and activities plus the roles and responsibilities for all parties involved. Additionally, it improves knowledge and comprehension of the design project.

Scope

The design project's scope is to improve mango sorting quality, minimize inspection time, and preserve consistency by creating a system for categorizing, grading, and sorting carabao mangoes based on machine

vision, physical appearance, and size, as well as mobile applications. The design's objectives are to improve the process of sorting carabao mangoes by using artificial intelligence to identify quality, as well as sensors such as weight sensors and ultrasonic sensors to detect the presence of carabao mangoes on the conveyor belt. The overall vision for the design project is to properly and precisely detect carabao mangoes, followed by the use of artificial intelligence to sort their quality.

Reference Documents

The design proposal includes a user manual that explains how to use the system as well as a mobile application to help them avoid problems. The manual includes instructions for using the system, features, and suggestions for what to do and what not to do. The Ensure manual guide includes detailed information about the design system, such as preparation, procedures, and safety considerations.

User-Oriented operational description

The system is simple to use; it will automatically detect and classify carabao mangoes using processing images and sensors; then, the system will sort the items into boxes based on predefined qualities, ensuring efficient and accurate sorting; and finally, the system can count mangoes detected and display the amount counted in real time on mobile applications. Mobile apps are critical for successfully transmitting

information, engaging users, streamlining data interpretation, and improving the overall user experience.

Operation Needs

The design project may include accurate detection and sorting of carabao mangoes. It can accurately detect decay in mangoes. It can accurately count trained carabao mangoes and lastly the system is on a real-time updates on the mobile application.

Operational Environment

The system will be set up at researchers place near to the cogeo public market antipolo rizal, therefore it must be designed to work indoors and guard against extreme elements including as heat, humidity, and physical risks. Ample room should be given to ensure a healthy working atmosphere and flow.

Operational Environment

Operation starts by user Interaction, users place a carabao mango on the weight sensor. The next stage will go through the conveyor belt to start the Rasp pi camera. camera detects carabao mangoes in real time, while AI algorithms examine their quality as they go along the conveyor belt. Using the classification findings from the AI and sensors, the system selects the right box for each quality and begins the sorting process which uses servo motors to direct mangoes into their appropriate boxes, based on their

quality categories. The mobile application delivers real-time updates, allowing users to track the amount of carabao mangoes that have been sorted.

4.13 Testing Results

The findings of the testing carried out in Chapter 3 are presented and discussed by researchers in this part.

4.13.1 Unit Testing

Table 4.2 Result of Component Testing

Component Testing	Expected Value	Test 1	Test 2	Test 3	Results	Average Value	Error%	Accuracy
Raspberry Pi 4 B	Boot time: 60s	60s	60s	60s	Working	60s	0%	100%
Arduino nano microcontroller	Boot time: 5s	5s	5s	5s	Working	5s	0%	100%
Arduino Uno microcontroller	Boot time: 5s	5s	5s	5s	Working	5s	0%	100%
Raspberry Pi Camera	Capture speed: 0.4 fps	0.4fps	0.4 fps	0.4 fps	Working	0.4 fps	0%	100%
Servo Motor	Angle: 180°	Angle: 180°	Angle: 180°	Angle: 180°	Working	Angle: 180°	0%	100%
Stepper Motor	Angle: 360°	Angle: 360°	Angle: 360°	Angle: 360°	Working	Angle: 360°	0%	100%
Continous servo motor	Angle: 360°	Angle: 360°	Angle: 360°	Angle: 360°	Working	Angle: 360°	0%	100%
Straight Bar Load Cell / Weight Sensor	Output: 349g>	Carabao Mango Large: 349g	Carabao Mango Large: 349g	Carabao Mango Large: 349g	Working	349g For large carabao mango	0%	100%

Ultrasonic Sensor	Output: Object Presence Detected	Whole Carabao Mango Output: Object Presence Detected	Whole Carabao Mango Output: Object Presence Detected	Whole Carabao Mango Output: Object Presence Detected	Working	ON	0%	100%

Table 4.2 presents the results of the tests conducted on the components, with researchers confirming that the components were functioning properly and aligning with the expected values. These values were determined from the completed tests, and the average value, error percentage, and accuracy percentage were calculated to enhance the clarity, validity, and reliability of the research findings, all aimed at refining the design.

4.13.2 System Testing an evaluation

This part displays the results of system detection,

Table 4.3 Result of Carabao Mango Object Detection

	Expected Value	**Test 1**	**Test 2**	**Test 3**	**Result**
Carabao Mango					
Ripe Mangoes	70% to 100%	98%	98%	98%	**High Threshold**
Raw Mangoes	70% to 100%	98%	97%	98%	**High Threshold**
Decay	70% to 1 0 0 %	86%	60%	86%	**High Threshold**

Average	70% to 100 %	94%	85%	94%	**High Threshold**

Table 4.3 displays the findings of the result of AI carabao mango detection, with researchers concluding that the tests reached the predicted values for detecting trained carabao mangoes that proceed to camera detection and passing conveyor belt. The percentage of detections produced by the researchers in Tests 1, 2, and 3 in terms of confidence levels demonstrates if AI object identification can recognize carabao mango based on quality and weight. The expected value serves as a reference for the actual test result. To confirm the correctness of the results, the researchers calculate the average value of tests 1, 2, and 3.

Table 4.4 Result of Hardware Detection

Components testing	Test 1 & Value	Test 2 & Value	Test 3 & Value	Actual Result	Average Value	Error %	Accuracy
Straight Bar Load Cell / Weight Sensor	Carabao Mango (Large) Output: 1 Read the weight size	Carabao Mango (Medium) Output: 1 Read the weight size	Carabao Mango (Small) Output: 1 Read the weight size	Carabao mango: Output: 1 Read all the weight data	Output: 1	0%	100%
Ultrasonic Sensor	Whole Carabao Mango Output: 1	Whole Carabao Mango Output: 1	Whole Carabao Mango Output: 1	Whole Carabao Mango Output: 1	Output: 1 ON	0%	100%

	Object Presence Detected	Object Presence Detected	Object Presence Detected	Object presence detected			

Table 4.4 Displaying the results of the tests run on the sensors is a major and important rule in our system. Researchers determined that the sensors could detect the carabao mango. The tests met the predicted values and computed the average value, error percentage, and accuracy percentage to improve the clarity, validity, and reliability of the study findings in order to build the design, the output 1 shows that the device is operating properly and that the carabao mango was detected.

Table 4.5 Result of System Gathered Data Collection

Date	Ripe	Unripe	Decay
March 10, 2025			
Small Size	4	8	Decayed mangoes of all sizes are being stored together in one container
Medium Size	5	1	
Large Size	4	2	
Total	13	11	
Overall Total	29		
March 11, 2025			
Small Size	2	4	

Medium Size	5	5	Decayed mangoes of all sizes are being stored together in one container
Large Size	3	2	
Total	10	11	4
Overall Total	25		
March 12, 2025			
Small Size	2	3	Decayed mangoes of all sizes are being stored together in one container
Medium Size	3	4	
Large Size	3	4	
Total	8	11	6
Overall Total	25		
March 13, 2025			
Small Size	2	1	Decayed mangoes of all sizes are being stored together in one container
Medium Size	3	2	
Large Size	4	6	
Total	9	9	4
Overall Total	22		
March 14, 2025			
Small Size	1	2	Decayed mangoes of all sizes are being stored together in one container
Medium Size	4	1	
Large Size	4	5	

Total	9	11	2
Overall Total	22		
March 17, 2025			
Small Size	5	0	Decayed mangoes of all sizes are being stored together in one container
Medium Size	2	1	
Large Size	6	4	
Total	13	5	9
Overall Total	27		
March 18, 2025			
Small Size	4	1	Decayed mangoes of all sizes are being stored together in one container
Medium Size	6	3	
Large Size	3	4	
Total	13	8	3
Overall Total	24		
March 19, 2025			
Small Size	1	1	Decayed mangoes of all sizes are being stored together in one container
Medium Size	3	2	
Large Size	9	8	
Total	13	11	9
Overall Total	33		

March 20, 2025			
Small Size	5	3	Decayed mangoes of all sizes are being stored together in one container
Medium Size	5	6	
Large Size	0	0	
Total	10	9	
Overall Total	19		
Total Sorted Carabao Mangoes	226		

The table shows the system's carabao mango sorting results over nine days, from March 10, 11, 12, 13, 14, 17, 18, 19, and 20, 2025. Each day, from 20 to 30+ carabao mangoes were sorted into three quality classifications (ripe, unripe, and decay) and weight categories (small, medium, and large). The findings demonstrate that Class Ripe regularly had the most carabao mangoes sorted, mainly in the large and medium size categories. Class Decay had half the quantity of mangoes compared to the ripe and raw mangoes, and Class unripe had fewer mangoes sorted compared to the ripe mangoes, particularly large-sized Carabao mangoes. At the end of nine days, the system had successfully sorted 226 carabao mangoes. The distribution of classes remained rather consistent during the recorded days, with Class Ripe receiving the most entries and Class Raw and Decay having fewer items processed.

Table 4.6 Overall Results of System Data Gathered per Class and Weight Size

Total Sorted Carabao Mango Per class	Ripe- 98	Unripe -86	Decay - 42
Total Sorted Carabao Mango Per Weight	Small Size - 49	Medium Size -61	Large Size - 71
Overall Total of sorted Carabao Mango	226		

The table presents the overall results of the system's carabao mango sorting process, summarizing the total number of mangoes sorted by class and size. Among the three classifications, Class Ripe had the highest count with 98 mangoes, followed by Class unripe with 86 mangoes and Class Decay with 42 mangoes. In terms of weight size distribution, large-sized mangoes accounted for the highest count at 71, followed closely by medium-sized mangoes with 61 and small-sized mangoes with 49. The total number of sorted carabao mangoes across all classes and sizes amounted to 226.

4.14 Survey Results

In this section, the researchers evaluate and report the survey results. The researchers utilize a horizontal bar graph to illustrate the survey results. Horizontal bar graphs make survey data interpretation easier and are the favored option when clarity and readability are critical. Weighted Average Formula is applied for obtaining the mean of each criterion and the overall

system evaluation. Survey questionnaire is based on ISO 25010 format. The questions provided were answered by 10 respondents.

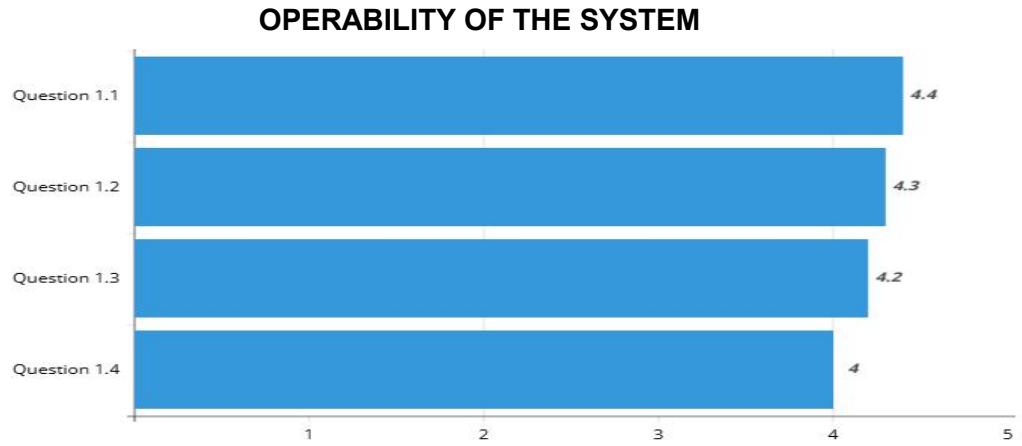


Figure 4.13 Mean Survey Ratings on System Operability

The graph indicates that selected respondents are strongly agree in the operability of the system. The graph shows that users find the system to be operating in a good speed, with the highest rating of (4.4 mean value). while question 1.4 is the lowest with (4 mean value). that prototype enough power to operate task.

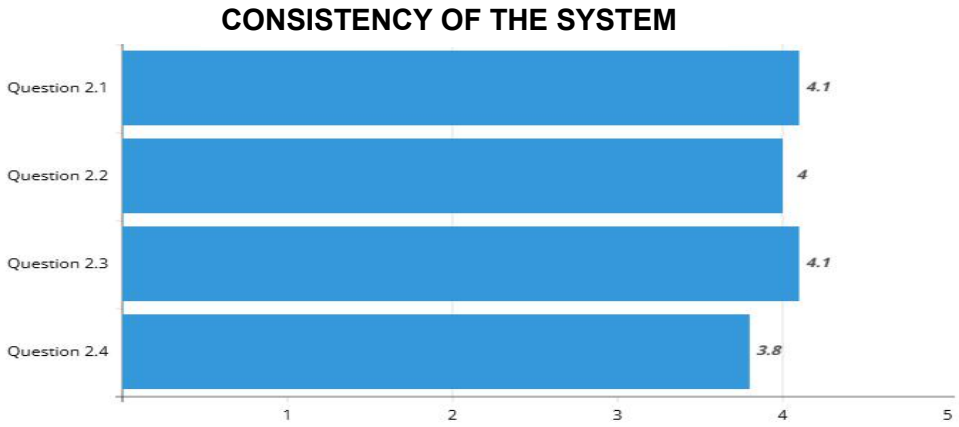


Figure 4.14 Mean Survey Ratings on System Consistency

The graph indicates that selected respondents are agree in system consistency. The graph shows that users find the system servo motor arm consistently sorts mangoes into their designated class and the system raspberry pi camera camera consistent in displaying mango, both questions have the highest rate of (4.1 mean value) while question 2.4 is the lowest with (3.8 mean value). that weight sensor consistently displaying weight of mango.

ACCURACY OF THE SYSTEM

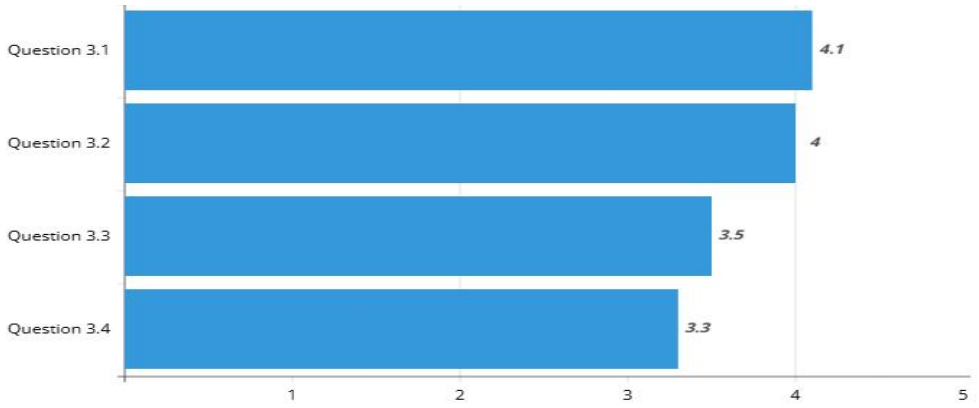


Figure 4.15 Mean Survey Ratings on System Accuracy

The graph indicates that selected respondents are agree in the accuracy of the system . The graph shows that users find the system AI based to be accurately detected the ripe mango., with the highest rating of (4.1 mean value). while question 3.4 is the lowest with (3.3 mean value).system accurately detected weight of mango.

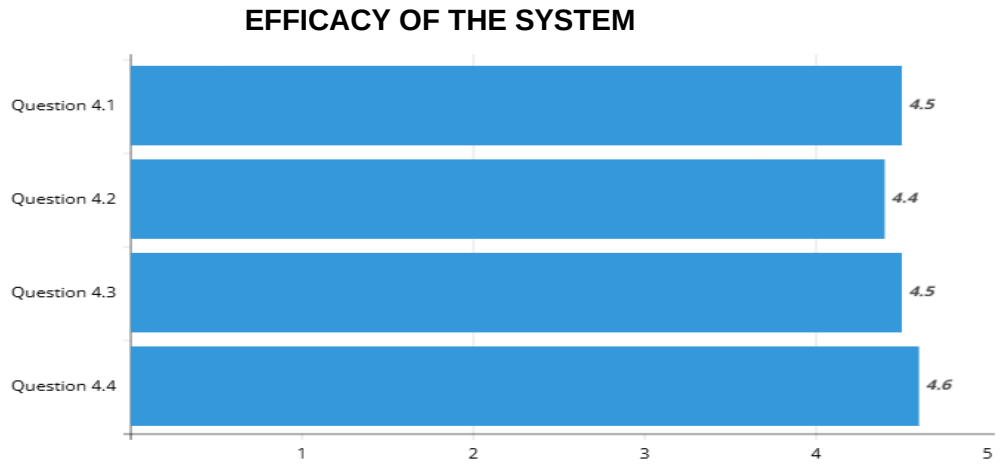


Figure 4.16 Mean Survey Ratings on System Efficacy

The graph indicates that selected respondents are strongly agree in the Efficacy of the system . The graph shows that users find the system hardware effective in prevents common issues in grading mango., with the highest rating of (4.6 mean value). while question 4.2 is the lowest with (4.4 mean value).The hardware provides a seamless and effective user experience.

Table 4.7 Mango Merchant Survey Results

1. Operability of the system to perform task	Mean	Verbal Interpretation
1.1 The prototype operates in good speed	**4.4**	Strongly Agree
1.2 The prototype have good sized mango container for operation	**4.3**	Strongly Agree
1.3 The performance of the database meets the operational requirements.	**4.2**	Strongly Agree
1.4 The prototype have enough power to operate task	**4**	Agree
Weighted mean average	**4.22**	
2. **Consistency provide uniform and repeatable results over time**		
2.1 The servo motor arm consistently sorts mangoes into their designated class	**4.1**	Agree
2.2 The mobile application consistent in presenting real time data	**4**	Agree
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango	**4.1**	Agree
2.4 The weight sensor consistently displaying weight of mango	**3.8**	Agree
Weighted mean average	**4**	
3. **Accuracy based on AI detections of mango**		
3.1 The system accurately detected the ripe mango.	**4.1**	Agree
3.2 The system accurately detected the unripe mango.	**4**	Agree
3.3 The system accurately detected the decay mango.	**3.5**	Agree
3.4 The system accurately detected weight of mango.	**3.3**	Agree
Weighted mean average	**3.72**	
4. Efficacy of mango sorting system		
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	**4.5**	Strongly Agree

4.2 The hardware provides a seamless and effective user experience.	**4.4**	Strongly Agree
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	**4.5**	Strongly Agree
4.4 The hardware is effective in minimizing common issues in grading mango.	**4.6**	Strongly Agree
Weighted mean average Overall Weighted Mean Average	**4.5** **4.11**	Strongly Agree

Table 4.5 shows the findings of the researchers' survey conducted at the public market of Cogeo Antipolo, primarily target is mango merchant who sold carabao mangoes. Carabao mango sorting system demonstrates excellent performance with an overall weighted mean of 4.11 (Strongly Agree). it achieves 4.22 in Operability of the system to perform task, the faster a system can process, decide, and act, the more effective and dependable it becomes. The Consistency provide uniform and repeatable results over time scores 4, the components of the system delivers the same results or behaves in the same way when given the same inputs or conditions every time. The accuracy based on AI detection's of mango scores 3.72. Accuracy refers to how correctly the AI system can identify or classify mangoes, detecting ripe, unripe mangoes, spotting defects, and counting them. The efficacy of mango sorting system scores 4.5. Efficacy means how effective the mango product, system, service is perceived to be and how satisfied people are with it.

Table 4.8 Respondent's common suggestion/Recommendations in the system

Respondent	Number of Respondent	Common suggestions/Recommendation
Mango Merchant	8	● The prototype should have much bigger container (5) ● The prototype needs to operate 2x faster (1) ● The mobile applications should be enhance more in terms of parties involved (2)

The table 4.8 presents the common suggestions and recommendations provided by 8 respondent mango merchants from Cogeo public market, Antipolo. Their feedback highlights the need for improvements in the prototype to enhance its efficiency and usability. Among the merchants, they emphasized the need for a much bigger container. Instead of transferring mangoes multiple times through small containers, a bigger one reduces excessive handling, helping to prevent bruising and spoilage. According to the one respondent, The prototype needs to operate two times faster than before; it will increase productivity as a faster machine sorts more mangoes in less time, boosting daily output and overall operational efficiency, and rapid sorting ensures mangoes spend less time in storage or transit, preserving freshness, texture, and taste. According to the two respondent The mobile application needs to be improved on a larger scale so that farmers, distributors, growers, sorters, packagers, logistics teams, and purchasers can have access to it, the respondent emphasized that the mobile app needs broader improvements to support access for all key users in the supply chain.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

This chapter presents a summary of the research findings, followed by the study's conclusion and suggestions.

5.1 Summary

The MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting" is designed to automate the traditionally manual process of sorting carabao mango, improving accuracy, efficiency, and productivity following the Philippine National Standard PNS/BAFPS 13:2004 for fresh fruit, The researchers system development integrates various technologies into the prototype, like integrating Artificial Intelligence (AI), Internet of Things (IoT), image processing (IM), and machine vision (MV) in the prototype. The devices communicate with each other to accurately sort mangoes according to their weight, size, and quality.

The researchers developed a mobile application for real-time monitoring of the number, quality, and weight size of carabao mangoes. Android Studio serves as the official Integrated Development Environment (IDE) for building Android apps. Figma is used to create user interfaces that may then be exported to Android Studio for development. TensorFlow was used to code and build AI carabao mango quality detection using the Raspberry Pi 4b, while the Arduino IDE was used to code the functionality

of components such as servo motors, straight bar load cell weight sensors, Ultrasonic sensors. The system operates in three stages: First, the hardware weight sensor, which determined the mangoes weight; second, the running conveyor, which used an AI-powered Raspberry Pi camera to detect and classify carabao mangoes; and the third stage, the ultrasonic sensor to detect the presence of mango to spin containers for sorting based on carabao mango classification.

The identified carabao mangoes are then sent to the database. The system includes mobile applications with real-time updates and categorized information. The administrator may monitor the system via the mobile application, which provides access to data such as the number of sorted mangoes by class and the merchant data.T he research has the potential in enhancing quality detection and accuracy, and stimulate innovation in the area of agricultural technology. Its effective deployment demonstrates the potential of AI-driven solutions to boost agricultural technology and modernize the processing of carabao mangoes.

5.2 Conclusion

The researchers found that the design project is valid and dependable. The electronic device efficiently satisfied the research goals. As a result, the researchers may conclude the following:

1. MangoQ: An AI-Based System for Carabao Mango Quality Detection

and Sorting Based on observations during the development and testing of the Enhanced AI-Powered Carabao Mango Sorting System, the results demonstrate that the system is capable of accurately identifying and sorting Carabao mangoes according to their weight and quality classification. The automation significantly reduced manual labor and human error, allowing for faster and more consistent sorting. It was also observed that the system performed reliably under different conditions, maintaining its accuracy in classifying mangoes based on the standards set by the Philippine National Standard for fresh fruits. Overall, the AI-powered approach proved to be efficient, practical, and beneficial for mango farmers and processors aiming to improve product quality and operational productivity.

2. The MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting Based on observations of the AI performance in the Carabao Mango Sorting System, the artificial intelligence component effectively analyzed and classified mangoes according to quality standards. The AI demonstrated consistent accuracy in detecting surface defects, and color variations, which are key indicators for quality grading. It was also observed that the system adapted well to variations in fruit appearance, maintaining reliability across multiple test runs. The use of AI significantly improved sorting speed and precision compared to manual methods,

proving its potential to enhance productivity in mango post-harvest processing. These results highlight the system's capability to deliver intelligent, data-driven decisions that support standardized and efficient mango sorting.

3. The respondents' evaluation confirms that the MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting demonstrates excellent performance across all assessed categories, achieving an overall weighted mean of 4.11 (Strongly Agree). the system excels in Operability of the system to perform task (4.4) The prototype operates in good speed, while its Consistency provide uniform and repeatable results over time (4.) the servo motor arm is consistently sort mangoes into their designated class and raspberry pi camera is consistent in capturing image of carabao mango. Accuracy based on AI detections of mango (3.72) the system accurately detect the ripe mango, while Efficacy of the mango sorting system (4.5) the hardware is effective in minimizing common issues in grading mangoes, These high ratings, based on the ISO 25010 quality model, indicate that the system has been successfully evaluated in terms of system operability, consistency, accuracy, and efficacy proving its potential to enhance agricultural advancement in terms of sorting carabao mango.

Overall, Based on the observations of the Enhanced AI-Powered Carabao Mango Sorting System, it is evident that the integration of artificial

intelligence has significantly improved the accuracy, efficiency, and consistency of mango sorting operations. The AI system reliably detects and sorts mangoes according to their weight and quality categories, adhering to the Philippine National Standard for fresh fruits. The system's ability to adapt to variations in fruit characteristics and perform under different conditions shows its robustness and practical value in a real-world setting. Throughout the testing phase, it was observed that the AI system not only streamlined the sorting process but also reduced the potential for human error, ensuring a more standardized and faster process. The overall productivity of mango sorting operations has been enhanced, offering long-term benefits to farmers and industry stakeholders by reducing labor costs, improving product quality, and enabling greater market competitiveness. This system is a promising step towards the modernization of mango processing, with substantial potential for scaling across the industry.

5.3 Recommendations

Based on the feedback gathered from the respondents, several improvements are suggested to enhance the functionality and efficiency of the MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting, To address these concerns, the following enhancements are proposed:Use newer components to improve performance and prevent issues during testing and deployment.

1. The prototype should be developed and enhanced more speed so that it can process a lot of mangoes; the conveyor speed belts increase throughput, responsiveness, and efficiency, all of which are important as you advance through satisfactory and need to increase production. According to the respondents, having a speedier conveyor will allow them to sort more mango. This decrease in labor costs over time is because the system runs continuously, reducing the requirement for big worker personnel.

2. The mobile application should be enhanced, displaying the data with extra functions. And to create a website with improved user communication, according to respondents, the website can improve communication among all parties involved in mango production and distribution, including growers, sorters, packagers, logistics teams, and purchasers, ensuring that everyone

is on the same page concerning goals and timelines.

3. The prototype should have much bigger containers, A Large containers, according to respondents, Larger containers can help optimize storage and shipping by packing mangoes more efficiently, decreasing the need for many smaller containers and increasing storage capacity. with more space, workers spend less time refilling or emptying the container, which leads to a more streamlined sorting process and faster throughput

REFERENCES

Alake, R. (2024). OpenCV Tutorial: Unlock the Power of Visual Data Processing. datacamp.com. https://www.datacamp.com/tutorial/opencv-tutorial

AstroShootingStars. (2022, April 27). How to Install Raspberri Pi camera and Troubleshoot errors | Upgrade Bios Firmware on Raspberry Pi [Video]. YouTube. https://www.youtube.com/watch?v=Z8cs1cRrc5A

Crane, J., Gazis, R. (2020). Bacterial black spot (BBS) of Mango in Florida. https://edis.ifas.ufl.edu/publication/HS1369

Dancalan, J. B., Espiritu, C. J., Harupay, C. P. E., Macuana, A. C. C., Paginag, G. E., & Rebuyon, R. G. (2023). D-IOT-BOX: An automated in-kind donation box and management system with image processing for Rizal Technological University - Pasig donation drives (Unpublished graduate thesis). Rizal Technological University - Pasig Campus

Flowerree, D. (2020, December 8). Growing organic mangoes in the Philippines. The Mango Factory. https://www.themangofactory.com/growing-mangoes/organic-mangoes/growing-organic-mangoes-in-the-philippines/

FREEDOM TECH. (2023, November 20). how to install yolo v8 on raspberry pi bookworm 64 bit & create your own custom model yolov8 [Video]. YouTube. https://www.youtube.com/watch?v=XzhTq-nk8GQ

Ghosh, A. (2024, February 2). YOLOV8 Object Tracking and Counting. LearnOpenCV – Learn OpenCV, PyTorch, Keras, Tensorflow With Code, & Tutorials. https://learnopencv.com/yolov8-object-tracking-and-counting-with-opencv/

Greengard, G. (2025, March 21). Internet of Things | Definition, History, Examples, & Privacy Concerns. Encyclopedia Britannica.https://www.britannica.com/science/Internet-of-Things

International Organization for standardization. (n.d.). What is artificial intelligence (AI)?ISO. https://www.iso.org/artificial-intelligence/what-is-ai

Iqbal, H. M. R., & Hakim, A. (2022). Classification and grading of harvested mangoes using convolutional neural network. International Journal of Fruit Science, 22(1), 95–109. https://doi.org/10.1080/15538362.2021.2023069

Jain, N. (2024, November 5). What is Technology Innovation? Definition, Examples and Strategic Management. IdeaScale. https://ideascale.com/blog/what-is-technology-innovation/

Jagdish. (2024, November 3). Mango Farming in Philippines: How to Start, Varieties, Planting, Care, and harvesting. Agri Farming. https://www.agrifarming.in/mango-farming-in-philippines-how-to-start-varieties-planting-care-and-harvesting

Lamsen, F. C. (2021, December 13). Automatic Mango fruit classifier using image processing through Pixel-Based calculation, correlation and logic system. https://tinyurl.com/43x5ze4e

Liwag, R. J. H., Cepria, K. J., Rapio, A., Castillo, K. L., & Cabatuan, M. K. (2019). Deep learning-based embedded system for carabao mango (Mangifera indica L.) sorting. Animo Repository. https://tinyurl.com/2p85we8n

Manliguez, C. (2019). Determining 'Carabao' Mango Ripeness Stages Using Three Image Processing Algorithms. https://tinyurl.com/mwrpsdtk

Mendez, S. (2024, January 22). PhilMech-made mango sorting machine expected to reduce production errors and optimize production process. DOST-PCAARRD Portal. https://tinyurl.com/2f97k3tu

Nandi, C. S., Tudu, B., & Koley, C. (2013). Machine vision based techniques for automatic mango fruit sorting and grading based on maturity level and size. In Smart sensors, measurement and instrumentation (pp. 27–46). https://doi.org/10.1007/978-3-319-02315-1_2

Nwaojigba, G. (2025, March 5). What is AI Image Processing? Your Quick Guide - Klippa. Klippa. https://www.klippa.com/en/blog/information/ai-image-processing/

PNS-BAFPS 13-2004. PHILIPPINE NATIONAL STANDARD. (2004). PNS-BAFPS 13-2004. PHILIPPINE NATIONAL STANDARD. (2004). https://tinyurl.com/4j5vdh5b

Psa.gov.ph. (2023). Major Fruit Crops Quarterly Bulletin, April-June. https://psa.gov.ph/major-fruit-crops/mango

Simbajon, L. G., Mata, G. L. C., Ilisan, D. A., & Ybañez, D. G. L. (2020). DigiMango: a digital postharvest evaluation tool on mango fruit. https://ejournals.ph/article.php?id=15790

Thinh, N. T., Thong, N. D., Cong, H. T., & Phong, N. T. T. (2019, November 1). Mango classification system based on machine vision and artificial intelligence. IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/8988603

Yossy, E. H., Pranata, J., Wijaya, T., Hermawan, H., & Budiharto, W. (2017). Mango Fruit Sortation System using Neural Network and Computer Vision. https://www.sciencedirect.com/science/article/pii/S1877050917320501.

Zelazko, A. (2025, February 1). RGB colour model | Description, Development, Uses, Science, & Facts. Encyclopedia Britannica. https://www.britannica.com/science/RGB-color-model

Zhou, Z., Zahid, U., Majeed, Y., Nisha, N., Mustafa, S., Sajjad, M. M., Butt, H. D., & Fu, L. (2023). Advancement in artificial intelligence for on-farm fruit sorting and transportation. Frontiers in Plant Science, 14. https://doi.org/10.3389/fpls.2023.1082860

APPENDICES

APPENDIX A

Project Proposal

PROJECT PROPOSAL

Title: MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting Rizal Technological University's Pasig Campus

A brief description of the system: Artificial intelligence-based fruit quality detection and sorting is done under the supervision of a progressive study of AI in order to benefit the next researcher, Rizal Technological University-Pasig Campus: the technology can recognize quality and automate the sorting of carabao mangoes, which will thrive and benefit farmers if developed and improved in the near future, The Design Project use Raspberry Pi and Arduino to construct the project and integrate AI fruit detection is used to determine the grade of carabao mangoes.

The researchers:

Cabaya,Carlos Anthony C.

Malubay, Keneth A.

Oliveros, Archie Jan E.

Pendre, Dan Joshua L.

Tala, Von Anthony B. Tala

Recommended by:

ENGR. RONEL D. PAGLOMUTAN

Adviser

Approved by:

ENGR. RIZAL LAQUI

Instructor

APPENDIX B

Trained Carabao Mangoes

The images below show ripe carabao mangoes used for training AI fruit detection. The researchers obtained high-quality photos of ripe carabao mangoes below to teach AI fruit identification.

RIPE MANGOES

The images below show semi-ripe carabao mangoes used for training AI fruit detection. The researchers obtained high-quality photos of ripe carabao mangoes below to teach AI fruit identification

SEMI-RIPE MANGOES

The images below show raw carabao mangoes used for training AI fruit detection. The researchers obtained high-quality photos of ripe carabao mangoes below to teach AI fruit identification.

RAW MANGOES

Annex A: Stages of ripeness of carabao mango fruit

Stage of ripeness	Peel color	Flesh color	Evidence
Green	Completely light green	Yellowish white or light yellow green	

Breaker	Traces of yellow	Middle area and fruit outline yellowish; other areas, white to yellowish white	
Turning	More green than yellow	More yellow than white	
Semi-ripe	More yellow than green 80-100% percent yellow (‘carabao’)	Yellow for ‘carabao’ Middle area yellow for ‘carabao’	
Overripe	Yellow for ‘carabao’	100% yellow or ‘carabao’	

Decay	Visibility of Dark spots,	Internal dark spot	

Annex B: Size classification of green carabao mango fruits

Size	Weight (g)	Evidence
Extra large	An extra-large carabao mango weighs over 350 grams or more.	
Large	A large carabao mango weighs between 300 and 349 grams.	

Medium	A medium carabao mango weighs between 250 and 299 grams.	
Small Super small	A small Carabao mango weighs between 200 and 249 grams, while super small mango weighs between 160 and 199 grams.	

APPENDIX C
Manual

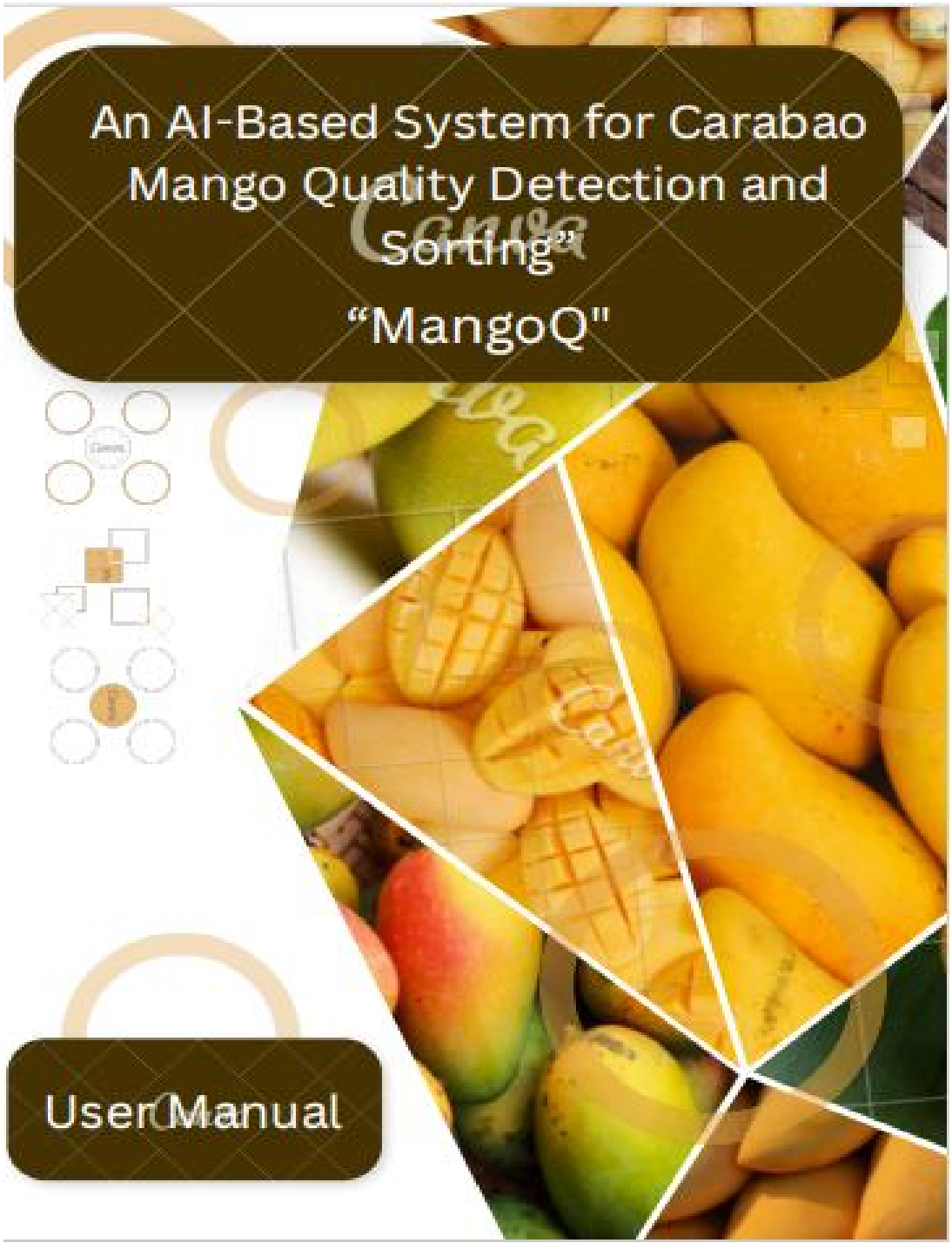
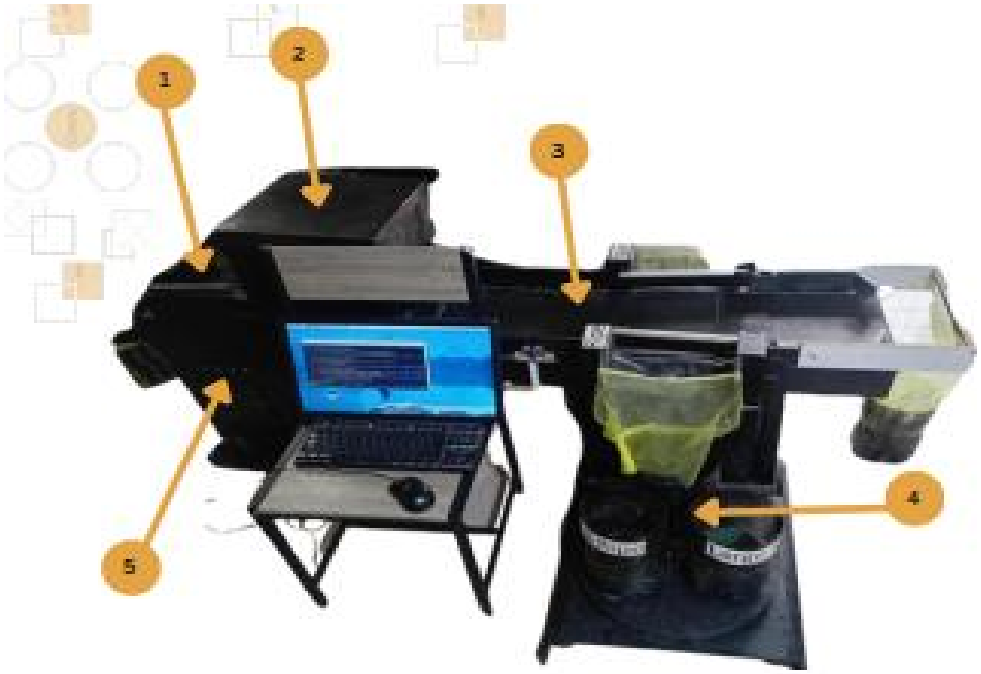

An AI-Based System for Carabao Mango Quality Detection and Sorting"
"MangoQ"
User Manual

Table of Contents



I. MangoQ Overview

1. **Weighing Handler** - The system weighs and classifies the mango before moving it to the camera station.
2. **Quality Inspection Belt** - The mini belt rotates the mango to capture images from all angles, then transfers it to the conveyor for sorting.
3. **Quality Sort Belt** - Conveyor Belt classifies the mango as Raw, Ripe, or Decay / Reject, sending to their designated container.
4. **Size Sort Spin Container** - If the mango is Raw or Ripe, it is sorted by size Small, Medium, or Large by rotating to its respective container.
5. **Power Switches** - Controls the power for the microcontroller, camera lights, conveyor belt, and mini belt.

II. Switch Function

Microcontroller Power: Turns the microcontroller on/off, controlling the system's overall functionality.

Camera Light: Powers the camera's lighting for proper image capture during inspection.

Sorting Conveyor Belt: Turns the sorting conveyor belt on/off to move mangoes through the sorting process.

Camera Mini Belt: Turns the mini belt on/off to rotate mangoes for 360-degree inspection by the camera.

- Each switch provides control over key components, allowing users to turn parts on or off for efficient operation, energy conservation, and easy maintenance. This enhances the MangoQ's flexibility and performance.

III. MangoQ Workflow

- **Enter Merchant Name**

The user enters the merchant's name into the system.

- **Place the Mango on the Scale**

Place a Carabao mango at the exact center of the scale and leaves it there.

- **Weight Classification**

The system classifies the mango by weight, then transfers it to the camera station.

- **Camera Inspection**

The system rotates the mango to capture images from all angles for further classification, then moves it to the conveyor for sorting.

- **Sorting by Quality (Raw, Ripe, or Decay / Reject):**

The system identifies the mango as Raw, Ripe, or Decay/Reject. If classified as Decay, it is directed to the Decay Container.

- **Size Sorting (If Raw or Ripe):**

If the mango is classified as Raw or Ripe, it is further sorted by size and directed to its respective container. If classified as Decay or Reject, it is directed to a single designated container.

- **Completion and Reset**

The system finishes sorting and directs the mango to the correct container. The merchant can choose to sort another mango by placing a new one on the scale to restart the process; if not, the system automatically terminates.

IV. Troubleshoot Tips and Maintenance

Troubleshooting Tips

- Machine Not Turning On
  - Check the power switch for the microcontroller, camera light, conveyor belt, and mini belt. Ensure they are all in the ON position.
  - Verify that the power supply is properly connected and functioning.
- Mango Not Moving on Conveyor Belt
  - Ensure the sorting conveyor belt is properly aligned and that there are no obstructions.
  - Check if the motor for the conveyor belt is receiving power from the driver.
- Camera Not Capturing Images
  - Check the camera light to ensure it is powered on.
  - Ensure that the camera module is securely connected to the system and properly calibrated.
- Mangoes Are Not Properly Sorted
  - Verify that the sorting algorithms for weight, quality, and size are correctly configured in the system.
  - Check if the sensors are clean and unobstructed.
- Mini Belt Not Rotating the Mango Properly
  - Ensure the servo motor controlling the mini belt is connected and functioning.

- Check for any obstructions or malfunctions in the mini belt's movement.

- Decayed Mango Not Going to the Decay Container
  - Check the decay classification sensor to ensure it is working properly.
  - Verify that the sorting mechanism is correctly routing decayed mangoes to the decay container.

Maintenance Tips

- Regularly Clean the Conveyor Belts
  - Clean both the sorting conveyor belt and mini belt to remove any residue or dirt that might interfere with movement.
  - Use a soft cloth or brush to prevent damage to the belts.
- Check for Wear and Tear on Belts and Motors
  - Regularly inspect the belts and motors for signs of wear. Replace parts if necessary to ensure smooth operation.
- Inspect and Clean Sensors
  - Clean the sensors and camera lens regularly to ensure accurate image capture and proper sorting. Use a soft microfiber cloth to avoid scratching.
- Lubricate Moving Parts
  - Lubricate the servo motors and other moving parts to keep them running smoothly. This prevents friction and ensures longevity.

- Check Wiring and Connections
  - Inspect all wiring for loose or disconnected cables, especially for the servo shield and stepper motor. Tighten connections as needed.
- Update Software and Calibration
  - Periodically check for software updates to ensure your system's sorting algorithms are optimized.
  - Recalibrate the system if it seems to be misclassifying mangoes or if sensors are giving incorrect readings.

V. Safety Precautions

- **Power Off Before Maintenance**

Always turn off the machine and disconnect the power supply before performing any maintenance or cleaning.

- **Avoid Contact with Moving Parts**

Keep hands and other body parts away from moving parts like the conveyor belts and servo motors to avoid injury.

- **Proper Wiring Handling**

Ensure that all wires are properly insulated and secured to prevent electrical hazards. Avoid pulling or tugging on wires.

- **Wear Appropriate Gear**

When working on the machine, wear safety gloves and protective eyewear to prevent injury from sharp objects or debris.

- **Inspect the Machine Regularly**

Conduct regular inspections of all components (motors, belts, sensors, microcontrollers, etc.) to ensure they are in proper working condition and free of defects.

- **Keep Work Area Clean**

Maintain a clean work environment to avoid tripping hazards and ensure smooth operation of the machine.

- **Follow Manual's Guidelines**

Always follow the provided user manual and safety guidelines to ensure safe and proper operation of the machine.

Frequent Asked Question (FAQ)

1. Why was the Mango Sorting Machine created?

The Mango Sorting Machine was developed to automate the sorting process based on quality and weight (size). It helps reduce manual labor, minimize human error, and improve the speed and accuracy of mango classification, making it more efficient for merchants and producers.

2. What is the purpose of the switches in the machine?

Each switch provides independent control for essential components such as the microcontroller, camera light, sorting conveyor belt, and mini belt. This allows efficient operation, energy saving, safety, and easy maintenance.

3. What happens during the camera inspection?
The mango is rotated using a mini belt, allowing the camera to capture images from all angles for accurate quality classification. After inspection, the mango is transferred to the conveyor for sorting.

4. How are mangoes transferred between modules without damage?
The mini belt and sorting conveyor are closely aligned to ensure a smooth handoff, minimizing the risk of scratches or drops during transfer.

5. Why is proper container alignment important?
Containers must be precisely aligned to ensure mangoes fall into the correct bins after sorting. This ensures clean separation based on quality and size.

MANGO-Q SORTING APP

User Manual

OVERVIEW

About Our App

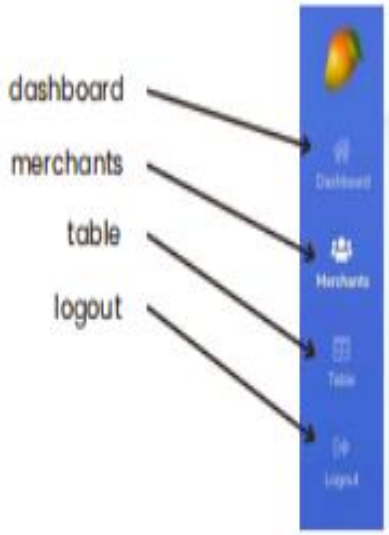
Our mobile application focuses on storing all the data, history, and information from all the merchants who use our machine. The app uses Firebase for secure, fast, and efficient data writing and reading. It is user-friendly and very easy to operate due to its minimalistic design.

1. LOGIN

The Mango Sorting App starts with a login page that uses Firebase Authentication to ensure the security of all the data inside the Firebase Realtime Database.

1. *Enter username and password*
2. *Click Login*

2. NAVIGATION BAR



The dashboard contains four buttons that allow the merchant to navigate: Dashboard, Merchants, Table, and Logout.

3. MERCHANT LIST

The Merchant page displays a table listing all merchants. The admin can archive merchants, add new ones, and view each merchant's username and password.

3.1. ARCHIVE MERCHANT

The admin can archive a merchant if sorting has been completed or if the merchant wants to hide their data.

1. *To archive a merchant, click the Archive button next to the desired merchant.*
2. *A confirmation dialog will appear – click Yes to proceed.*

3.2. MERCHANT CREDENTIAL

The admin can view a merchant's username and password by clicking on the merchant's name in the table.

1. *Click on any merchant name in the table.*
2. *A dialog will appear displaying the merchant's username and password. Click OK to close it.*

3.3. ADD MERCHANT

The admin can add a merchant's name and register their username and password.

1. *Enter the merchant's name in the top input box, then click the plus (+) button next to it.*
2. *A dialog will appear – enter the merchant's username and password.*
3. *Click Register to complete the process.*

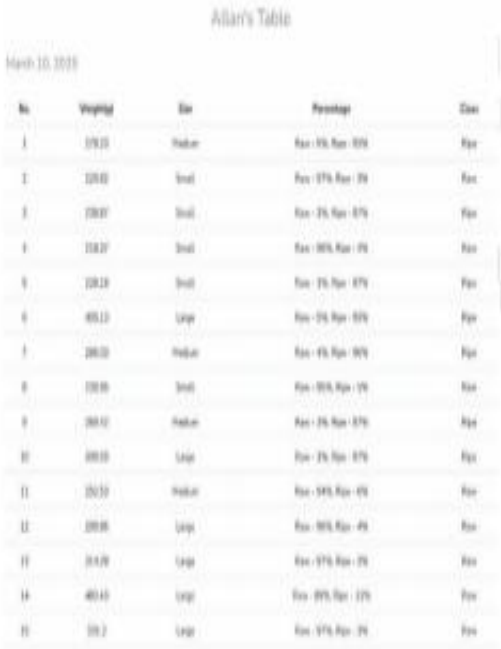
4. DASHBOARD

The dashboard can be accessed by both the admin and merchants, displaying all merchant data. The data can be filtered using a dropdown menu. Dashboard cards can be flipped to reveal additional information.

5. TABLE

The table can be accessed by both the admin and merchants, displaying all merchant data. The data can be filtered using a dropdown menu. A Generate Report button is also available for exporting or viewing summarized data.

6. GENERATED REPORT



After clicking the Generate Report button, the report will be saved as a PDF file and automatically stored in the device's storage.

APPENDIX D

Building Prototype and Data Gathering

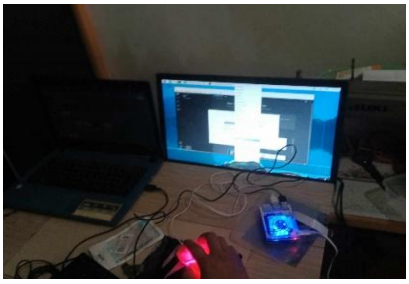
The photos below demonstrate the process of creating a prototype of MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting, from design to testing.






During this time, we worked on building the base or casing of our prototype. All the wood crafting and the compartments for the hardware components were made during this period. We completed this at Blk. 1, Banana St., Pinesville Subdivision, Dolores, Taytay, Rizal.





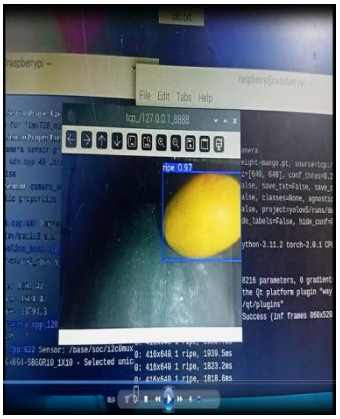
Here, we worked on setting up our hardware components, such as attaching the leather to our conveyors, installing the servo, and setting up the Raspberry Pi camera along with its mounting. We did this at BLK 24, Damayan, San Juan, Taytay, Rizal.

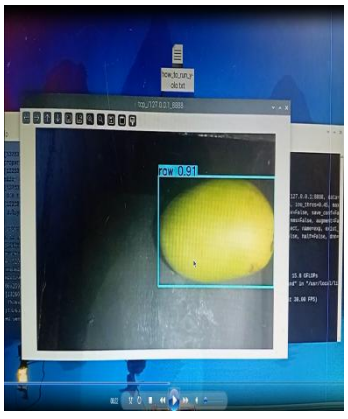
Data Gathering

The image below documents the data-gathering process, the testing, and the evaluation of the AI-powered carabao mango sorting system, where images and measurements of carabao mango are collected.







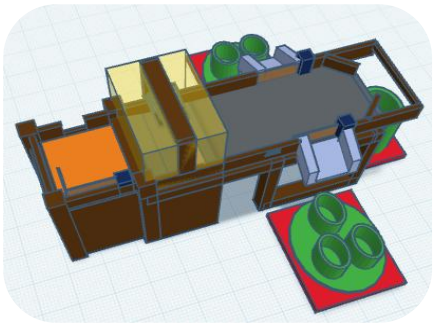


APPENDIX E

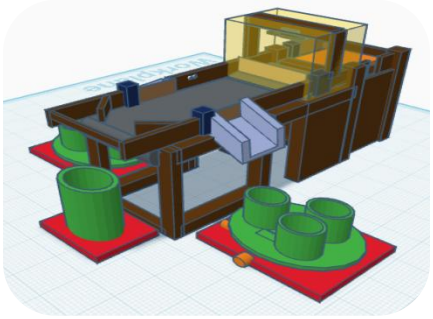
Prototype Design & Actual layout

Design Layout

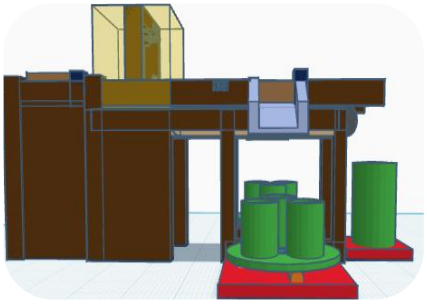
The image below shows the design layout of a proposed system; the researcher used TinkerCad, a 3D modeling software, to create the design. The layout is almost identical to the actual layout; 3D for hardware layout enhances design accuracy, efficiency, and collaboration, leading to better product performance and reliability.



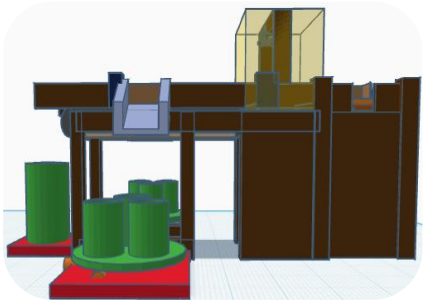
Isometric View



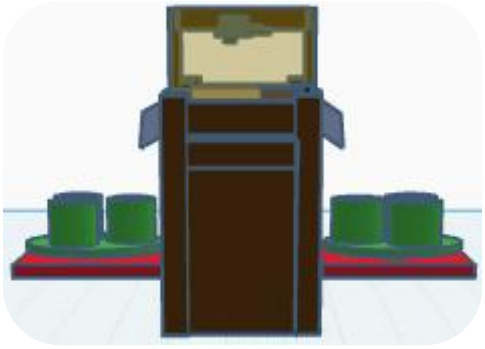
Back Angle View



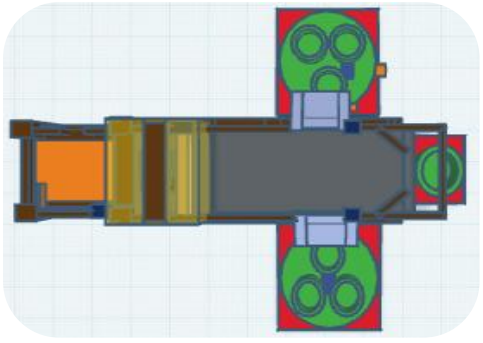
Right-Side View



left-Side View



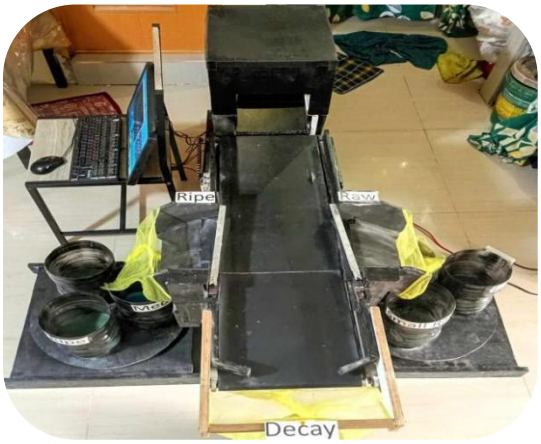
Back View

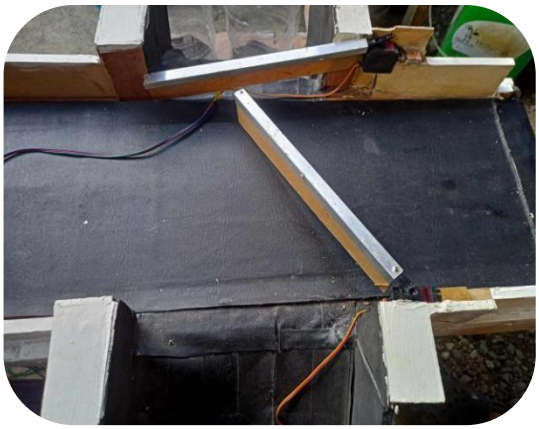


Top View

Actual Design

The image below shows the recommended system's real layout; it may alter significantly from the initial design or the TinkerdCad 3D model due to implementation adjustments-including relevant photographs can make the thesis more engaging and easier to read, especially for those unfamiliar with the subject..

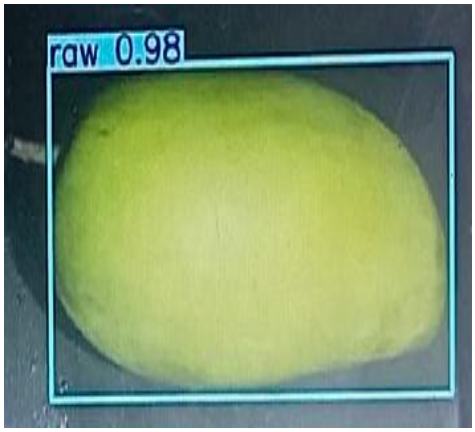




APPENDIX F

Testing:AI Carabao Mango Detection

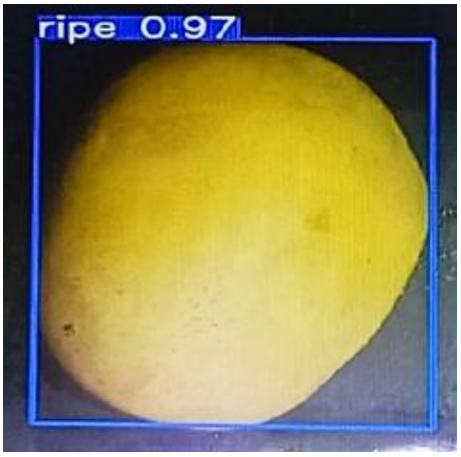
The Images below are the result of AI Carabao Mango detection tested by the researchers.




ripe 0.98


ripe 0.98


ripe 0.98

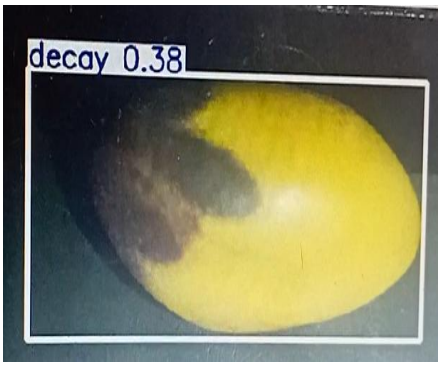

ripe 0.97


ripe 0.98


ripe 0.98


decay 0.84


decay 0.86


decay 0.38


decay 0.60


decay 0.84


decay 0.86

APPENDIX G

Walk Through

Structured Walkthrough

( ) Documentations
(/) System

Date of Walkthrough: 02-08-2025
Time: 1:00 pm - 2:00 pm

Title of the Project: Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes A.I.F.Q.D.S

Name of Proponents:

1. Cabaya, Carlos Anthony C.
2. Malubay, Keneth A.
3. Oliveros, Archie Jan E. (Leader)
4. Pendre, Dan Joshua L.
5. Tala, Von Anthony B

Engr. Ronel Paglomutan
Adviser

Action Recommended (Please choose one):
(/) Accept work as Found
( ) Revise work
( ) Work and conduct following up walkthrough
( ) Reject work

Structured Walkthrough

(/) Documentations

(/) System

Date of Walkthrough: 01/25/2025

Time: 01:00 PM

Title of the Project: Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes A.I.F.Q.D.S

Name of Proponents:

1. Cabaya, Carlos Anthony C.
2. Malubay, Keneth A.
3. Oliveros, Archie Jan E. (Leader)
4. Pendre, Dan Joshua L.
5. Tala, Von Anthony B

Engr. Ronel Paglomutan
Adviser

Action Recommended (Please choose one):

(/) Accept work as Found

( ) Revise work

( ) Work and conduct following up walkthrough

( ) Reject work

Structured Walkthrough

( ) Documentations
(/) System

Date of Walkthrough: Feb. 01, 2025
Time: 01:00 PM

Title of the Project: **Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes A.I.F.Q.D.S**

Name of Proponents:

1. **Cabaya, Carlos Anthony C.**
2. **Malubay, Keneth A.**
3. **Oliveros, Archie Jan E. (Leader)**
4. **Pendre, Dan Joshua L.**
5. **Tala, Von Anthony B**

Engr. Ronel Paglomutan
Adviser

Action Recommended (Please choose one):
( ) Accept work as Found
(/) Revise work
(/) Work and conduct following up walkthrough
( ) Reject work

Structured Walkthrough

( ) Documentations
(/) System

Date of Walkthrough: 02-08-2025
Time: 1:00 pm - 2:00 pm

Title of the Project: Innovative Artificial Intelligence-Based Fruit Quali Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishin Quality of Carabao Mangoes A.I.F.Q.D.S

Name of Proponents:

1. Cabaya, Carlos Anthony C.
2. Malubay, Keneth A.
3. Oliveros, Archie Jan E. (Leader)
4. Pendre, Dan Joshua L.
5. Tala, Von Anthony B

Engr. Ronel Paglomutan
Adviser

Action Recommended (Please choose one):
(/) Accept work as Found
( ) Revise work
( ) Work and conduct following up walkthrough
( ) Reject work

Structured Walkthrough

( ) Documentations

(/) System

Date of Walkthrough: March 09, 2025

Time: 03:00 PM

Title of the Project: Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes A.I.F.Q.D.S

Name of Proponents:

1. Cabaya, Carlos Anthony C.
2. Malubay, Keneth A.
3. Oliveros, Archie Jan E. (Leader)
4. Pendre, Dan Joshua L.
5. Tala, Von Anthony B

Engr. Ronel Paglomutan

Adviser

Action Recommended (Please choose one):

(/) Accept work as Found

(/) Revise work

( ) Work and conduct following up walkthrough

( ) Reject work

Structured Walkthrough

( ) Documentations
(/) System

Date of Walkthrough: 03-15-2025
Time: 01:00 PM

Title of the Project: Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality o Carabao Mangoes A.I.F.Q.D.S

Name of Proponents:

1. Cabaya, Carlos Anthony C.
2. Malubay, Keneth A.
3. Oliveros, Archie Jan E. (Leader)
4. Pendre, Dan Joshua L.
5. Tala, Von Anthony B

Engr. Ronel Paglomutan
Adviser

Action Recommended (Please choose one):
(/) Accept work as Found
( ) Revise work
( ) Work and conduct following up walkthrough
( ) Reject work

APPENDIX H

Survey Questionnaire

Survey Questionnaire

Survey questionnaire for mango merchant of Cogeo public market Antipolo Rizal

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering,
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting. We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): _____ **Gender:** _____

Occupation:_____ **Date:**_____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question					
1 . Operability of the system to perform tasks	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.1 The prototype operates in good speed					
1.2 The prototype have good sized mango container for operation					
1.3 The performance of the database meets the operational requirements.					
1.4 The prototype have enough power to operate task.					
2. 2. Consistency provide uniform and repeatable results overtime					
2.1 The servo motor consistently sorts mangoes into their designated class					
2.2 The mobile application consistent in presenting real time data					
2.3 The Raspberry pi camera camera consistent in displaying mango					
2.4 The weight sensor consistently displaying weight of mango					

3. Accuracy based on AI detections of mango					
3.1 The system accurately detect the ripe mango.					
3.2 The system accurately detect the raw mango.					
3.3 The system accurately detect the decay mango.					
3.4 The system accurately detect weight of mango.					
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.					
4.2 The hardware provides a seamless and effective user experience.					
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.					
4.4 The hardware is effective in prevents common issues in grading mango.					

5 Any recommendation and suggestion will be appreciated,
_____
_____
_____
_____
_____

APPENDIX I

Raw Data

Mango Merchant Survey Result

	SA 5	A 4	N 3	D 2	SD 1	SA(5)	A(4)	N(3)	D(2)	SD(1)	Total	Weighted Mean	Visual Interpretation
1. Operability of the system to perform tasks;													
1.1 The prototype operates in good speed	6	3	0	1	0	30	12	0	2	0	44	4.4	Strongly Agree
1.2 The prototype have good sized mango container for operation	5	4	0	1	0	25	16	0	2	0	43	4.3	Strongly Agree
1.3 The performance of the database meets the operational requirements.	5	2	3	0	0	25	8	9	0	0	42	4.2	Strongly Agree
1.4 The prototype have enough power to operate task	5	2	2	0	1	25	8	6	0	1	40	4	Agree
2. Consistency provide uniform and repeatable results over time													
2.1 The servo motor consistently sorts mangoes into their designated class	3	5	2	0	0	15	20	6	0	0	41	4.1	Agree
2.2 The mobile application consistent in presenting real time data	2	6	2	0	0	10	24	6	0	0	40	4	Agree
2.3 The Raspberry pi camera camera consistent in displaying mango	2	7	1	0	0	10	28	3	0	0	41	4.1	Agree
2.4 The weight sensor consistently displaying weight of mango	1	7	1	1	0	5	28	3	2	0	38	3.8	Agree
3. Accuracy based on AI detections of mango													
3.1 The system accurately detect the ripe mango.	4	5	0	0	1	20	20	0	0	1	41	4.1	Agree
3.2 The system accurately detect the raw mango.	4	3	2	1	0	20	12	6	2	0	40	4	Agree
3.3 The system accurately detect the decay mango.	1	7	0	0	2	5	28	0	0	2	35	3.5	Agree
3.4 The system accurately detect weight of mango.	2	4	1	1	2	10	16	3	2	2	33	3.3	Agree
4. Efficacy of mango sorting system													
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	6	3	1	0	0	30	12	3	0	0	45	4.5	Strongly Agree
4.2 The hardware provides a seamless and effective user experience.	5	4	1	0	0	25	16	3	0	0	44	4.4	Strongly Agree
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	6	3	1	0	0	30	12	3	0	0	45	4.5	Strongly Agree
4.4 The hardware is effective in prevents common issues in grading mango.	6	4	0	0	0	30	16	0	0	0	46	4.6	Strongly Agree

Scale	Numerical Values	Verbal Interpretation
5	4.20 – 5.00	Strongly Agree
4	3.40 – 4.19	Agree
3	2.60 – 3.39	Neutral
2	1.80 – 2.59	Disagree
1	1.00 – 1.79	Strongly Disagree

The Image shown above are result of the survey conducted by the researchers to the mango merchant of cogeo public market Antipolo rizal.

Respondent's Survey Raw Data

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Alan Aninon **Gender:** _____

Occupation: Merchant mango **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed		✓			
1.2 The prototype have good sized mango container for operation		✓			
1.3 The performance of the database meets the operational requirements.		✓			
1.4 The prototype have enough power to operate task		✓			
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class		✓			
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango		✓			

3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.					✓
3.2 The system accurately detected the unripe mango.		✓			
3.3 The system accurately detected the decay mango.					✓
3.4 The system accurately detected weight of mango.					✓
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.		✓			
4.2 The hardware provides a seamless and effective user experience.	✓				
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.			✓		
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

5 Any recommendation and suggestion will be appreciated,

Maganda Pag ka Malaki container mas

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable o Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Kevin Sarmines **Gender:** _____

Occupation: Distributor **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation	✓				
1.3 The performance of the database meets the operational requirements.	✓				
1.4 The prototype have enough power to operate task	✓				
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class		✓			
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango		✓			
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.	✓				
3.2 The system accurately detected the unripe mango.	✓				
3.3 The system accurately detected the decay mango.	✓				
3.4 The system accurately detected weight of mango.	✓				
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.	✓				
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.			✓		

5 Any recommendation and suggestion will be appreciated,

Mas palakihin pa ang container.

RIZAL TECHNOLOGICAL UNIVERSITY

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Bryan **Gender:** _____

Occupation: Merchant **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed		✓			
1.2 The prototype have good sized mango container for operation		✓			
1.3 The performance of the database meets the operational requirements.			✓		
1.4 The prototype have enough power to operate task	✓				
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class	✓				
2.2 The mobile application consistent in presenting real time data	✓				
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango			✓		

3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.		✓			
3.2 The system accurately detected the unripe mango.	✓				
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.			✓		
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.		✓			
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.			✓		
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

5 Any recommendation and suggestion will be appreciated,

palakihin pa ang kapa container

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Josh NATHANIEL SABAT **Gender:** _____

Occupation: Vendor **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation	✓				
1.3 The performance of the database meets the operational requirements.	✓				
1.4 The prototype have enough power to operate task	✓				
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class		✓			
2.2 The mobile application consistent in presenting real time data			✓		
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango			✓		
2.4 The weight sensor consistently displaying weight of mango				✓	

3 Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.	✓				
3.2 The system accurately detected the unripe mango.			✓		
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.				✓	
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.		✓			
4.2 The hardware provides a seamless and effective user experience.			✓		
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.		✓			
4.4 The hardware is effective in minimizing common issues in grading mango.			✓		

5 Any recommendation and suggestion will be appreciated,

Paki gandahan ang itsura ng app nyo. Kac Mas Maganda pag Malaki

RIZAL TECHNOLOGICAL UNIVERSITY

College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Mark [illegible] **Gender:** _____

Occupation: Vendor **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation	✓				
1.3 The performance of the database meets the operational requirements.	✓				
1.4 The prototype have enough power to operate task	✓				
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class			✓		
2.2 The mobile application consistent in presenting real time data			✓		
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango		✓			
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.	✓				
3.2 The system accurately detected the unripe mango.	✓				
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.	✓				
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.	✓				
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

5 Any recommendation and suggestion will be appreciated,

_____
_____
_____
_____
_____

RIZAL TECHNOLOGICAL UNIVERSITY

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Cynthia **Gender:** _____

Occupation: Vendor **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation	✓				
1.3 The performance of the database meets the operational requirements.	✓				
1.4 The prototype have enough power to operate task	✓				
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class	✓				
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango	✓				
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.		✓			
3.2 The system accurately detected the unripe mango.		✓			
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.		✓			
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.	✓				
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

5 Any recommendation and suggestion will be appreciated,

mas pabilisin pa yung process ng app

RIZAL TECHNOLOGICAL UNIVERSITY

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): LYRA MAE CORPUZ **Gender:** _____

Occupation: MERCHANT **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation		✓			
1.3 The performance of the database meets the operational requirements.		✓			
1.4 The prototype have enough power to operate task		✓			
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class		✓			
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango		✓			
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.		✓			
3.2 The system accurately detected the unripe mango.		✓			
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.		✓			
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.		✓			
4.2 The hardware provides a seamless and effective user experience.		✓			
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.		✓			
4.4 The hardware is effective in minimizing common issues in grading mango.		✓			

5 Any recommendation and suggestion will be appreciated,

MAS MADALAS ANG PAG-OPERATE NG SYSTEM

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Elisa fe aying **Gender:** _____

Occupation: Merchant **Date:** _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed				✓	
1.2 The prototype have good sized mango container for operation				✓	
1.3 The performance of the database meets the operational requirements.			✓		
1.4 The prototype have enough power to operate task					✓
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class		✓			
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango	✓				
2.4 The weight sensor consistently displaying weight of mango		✓			
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.	✓				
3.2 The system accurately detected the unripe mango.		✓			
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.		✓			
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.			✓		
4.2 The hardware provides a seamless and effective user experience.		✓			
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.		✓			

5 Any recommendation and suggestion will be appreciated,

Mas maliit pa sana ang container. Ito nahirapkto yun sa dami na malalagyan

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligen Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatev information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Edgar Dizon Miran **Gender:** ____

Occupation: Merchant **Date:** ____

Instruction. On the given tables below, rate each statement accordingly. Put a che (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed	✓				
1.2 The prototype have good sized mango container for operation	✓				
1.3 The performance of the database meets the operational requirements.	✓				
1.4 The prototype have enough power to operate task			✓		
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class	✓				
2.2 The mobile application consistent in presenting real time data	✓				
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango	✓				
2.4 The weight sensor consistently displaying weight of mango		✓			
3. Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.	✓	✓			
3.2 The system accurately detected the unripe mango.	✓				
3.3 The system accurately detected the decay mango.		✓			
3.4 The system accurately detected weight of mango.		✓			
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.		✓			
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

5 Any recommendation and suggestion will be appreciated,

Mas maraming na container

RIZAL TECHNOLOGICAL UNIVERSITY
College of Engineering
M. Eusebio Avenue, Maybunga, Pasig City

SURVEY QUESTIONNAIRE

We thank you for your participant on the study "Innovative Artificial Intelligence-Based Fruit Quality Detection and Sorting: Constructing an Enhanced AI Capable of Distinguishing Quality of Carabao Mangoes (A.I.F.Q.D.S)". We assure that whatever information you provide will be kept in the strictest confidentiality.

RESPONDENT'S PROFILE

Name(optional): Mr. Jason Vergara Gender: _____

Occupation: Engineer Date: _____

Instruction. On the given tables below, rate each statement accordingly. Put a check (check) on the provided space on the table

SA - strongly agree A - agree D - disagree SD - strongly disagree

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Operability of the system to perform task					
1.1 The prototype operates in good speed		✓			
1.2 The prototype have good sized mango container for operation		✓			
1.3 The performance of the database meets the operational requirements.			✓		
1.4 The prototype have enough power to operate task			✓		
2. Consistency provide uniform and repeatable results over time					
2.1 The servo motor arm consistently sorts mangoes into their designated class			✓		
2.2 The mobile application consistent in presenting real time data		✓			
2.3 The Raspberry pi camera is consistent in capturing image of carabao mango		✓			
2.4 The weight sensor consistently displaying weight of mango		✓			

3 Accuracy based on AI detections of mango					
3.1 The system accurately detected the ripe mango.		✓			
3.2 The system accurately detected the unripe mango.				✓	
3.3 The system accurately detected the decay mango.					
3.4 The system accurately detected weight of mango.					✓
4. Efficacy of mango sorting system					
4.1 Technical support and troubleshooting for the hardware are readily available and effective.	✓				
4.2 The hardware provides a seamless and effective user experience.					
4.3 Overall, I am satisfied with the performance and effectivity of the hardware.	✓				
4.4 The hardware is effective in minimizing common issues in grading mango.	✓				

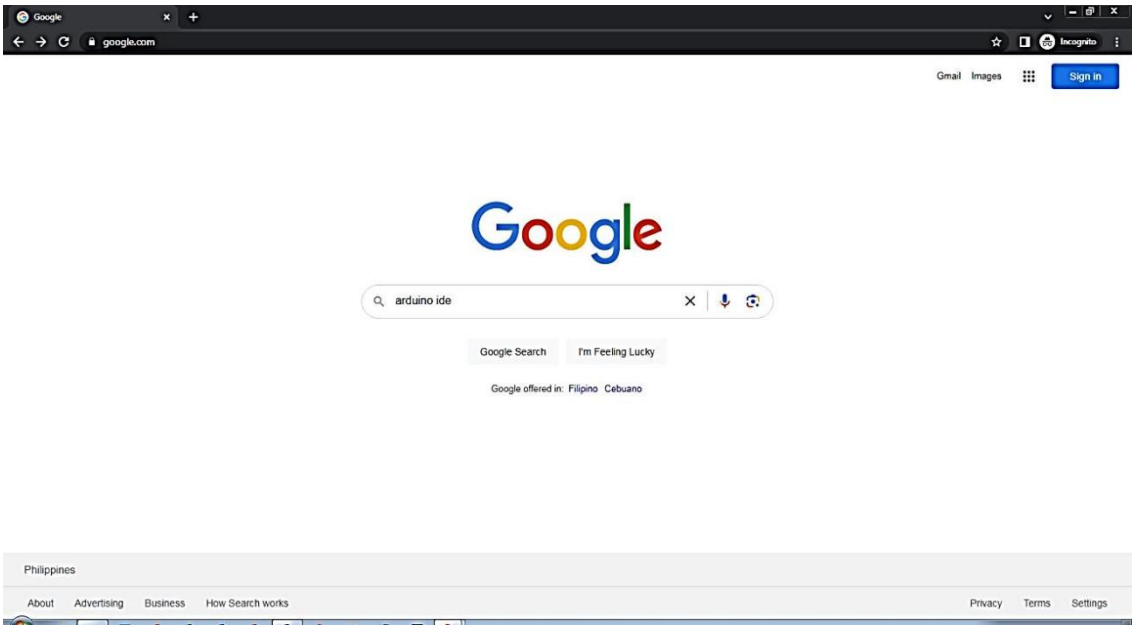
5 Any recommendation and suggestion will be appreciated,

consistency

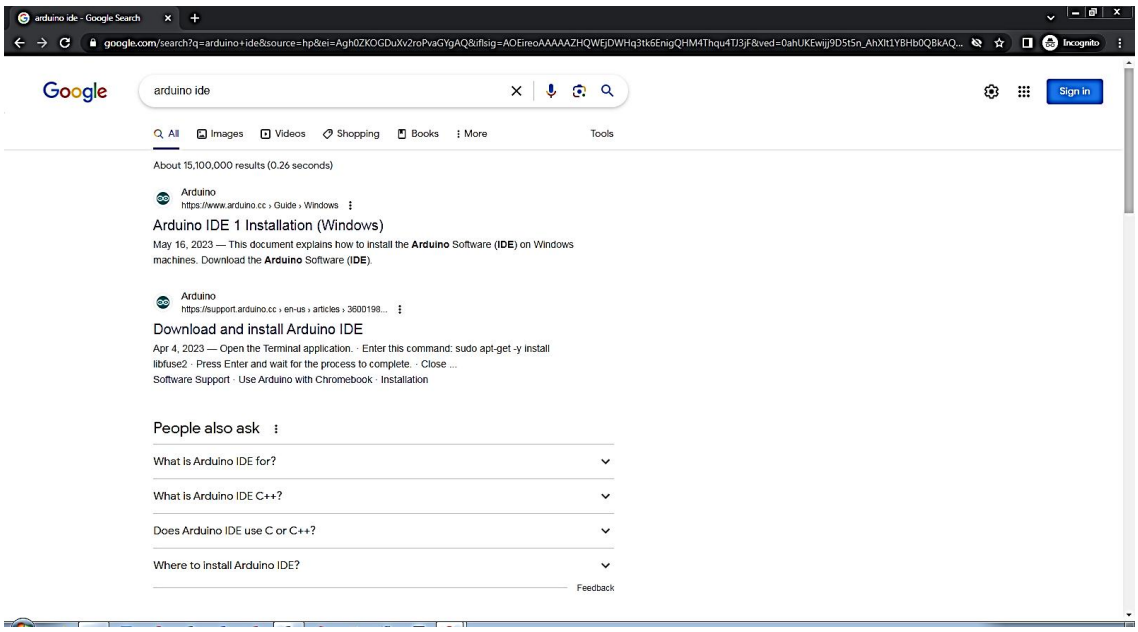
APPENDIX J
Installation

Arduino IDE installation (Windows)

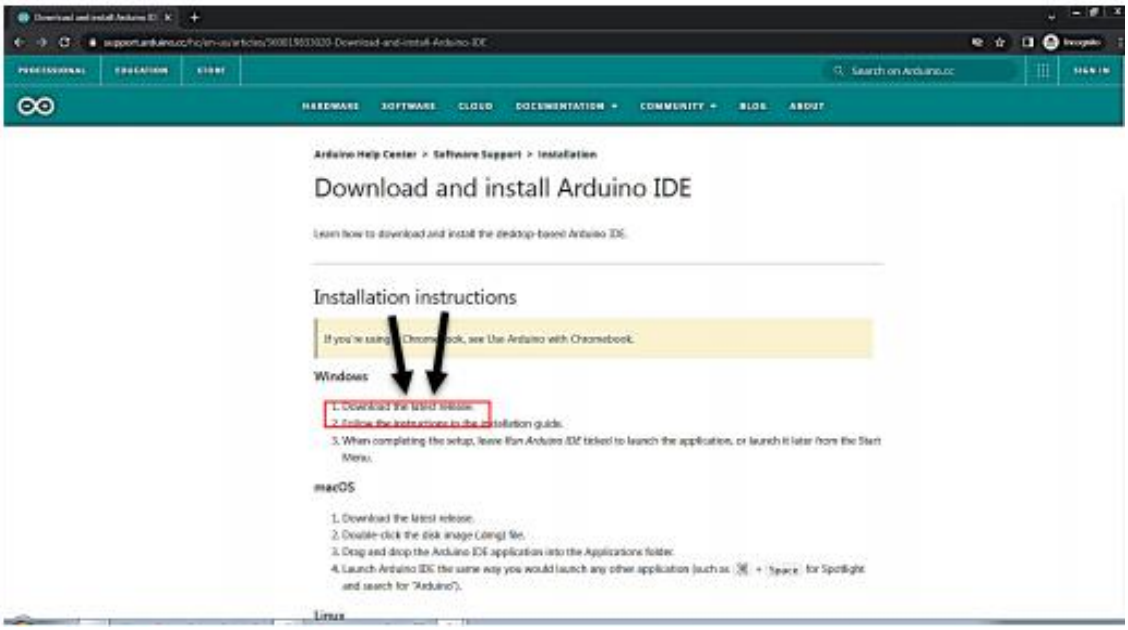
Step 1: Type Arduino IDE on the google search bar and hit enter



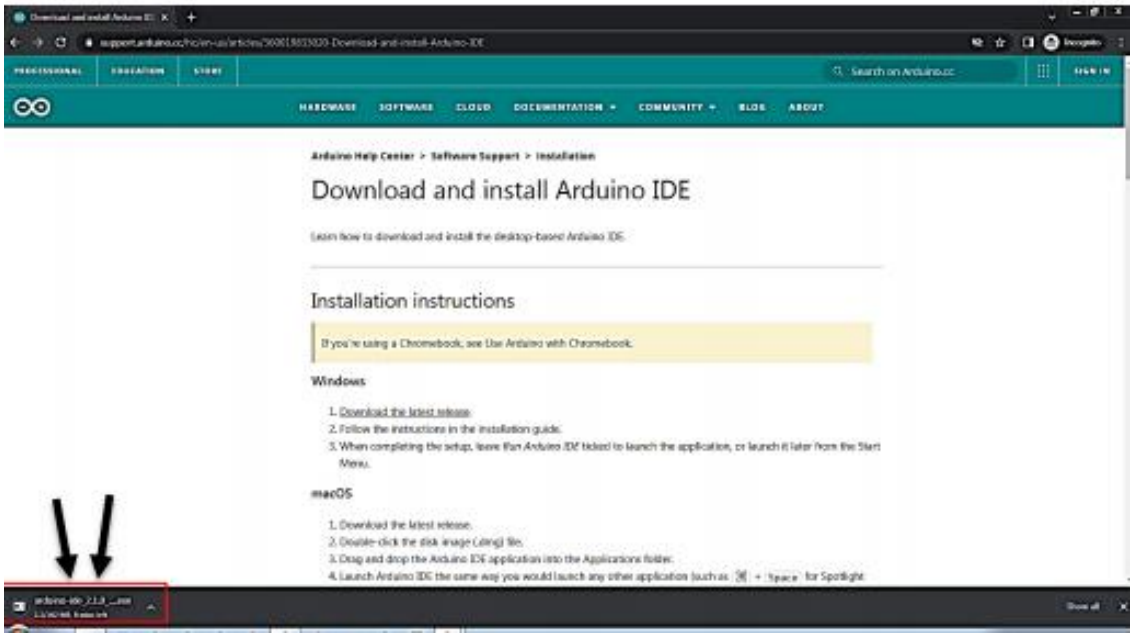
Step 2: Click the highlighted text to download the exe file of the Arduino IDE.



Step 3: Click the highlighted “Download the latest version”. To start the downloading of the exe file

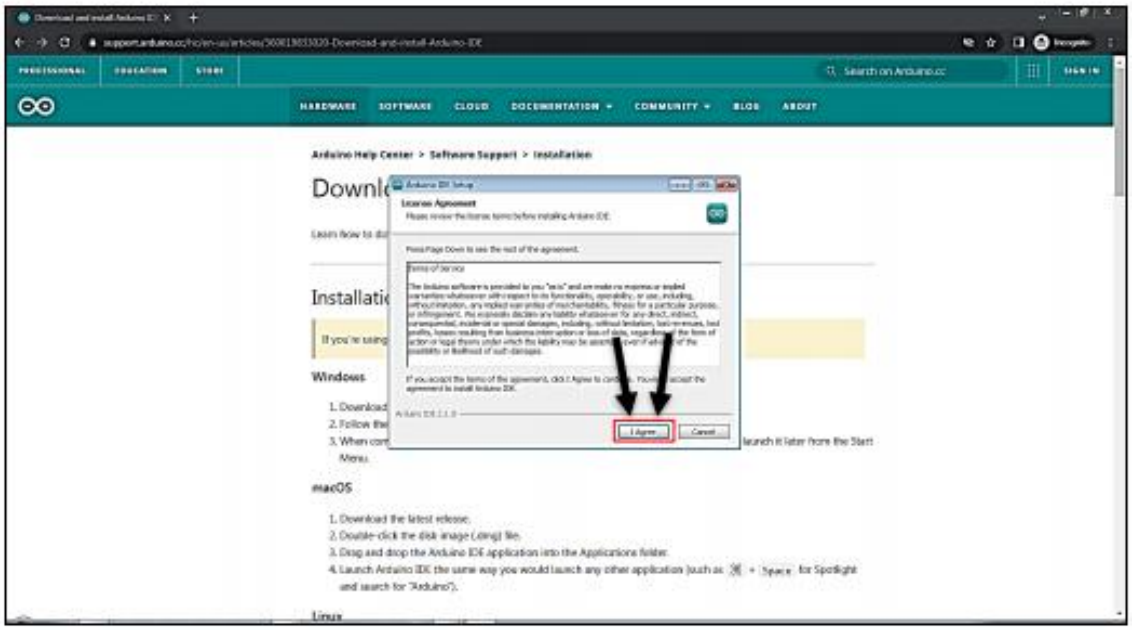


Step 4: Wait until the exe file finish downloading

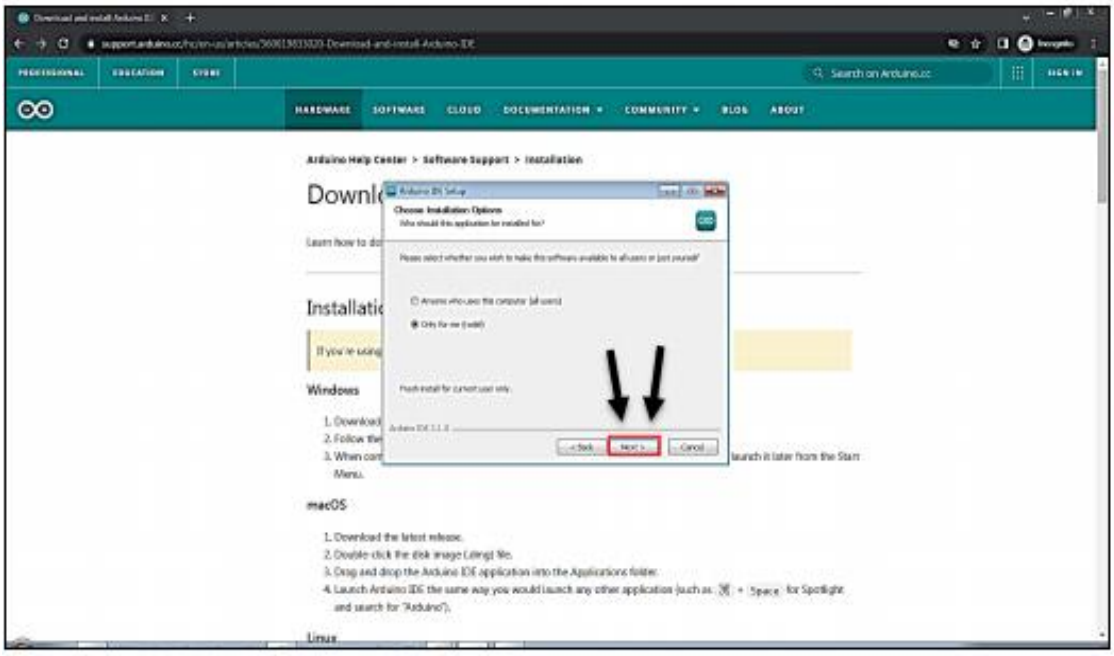


Step 5: After downloading, click the exe file then click the run button.

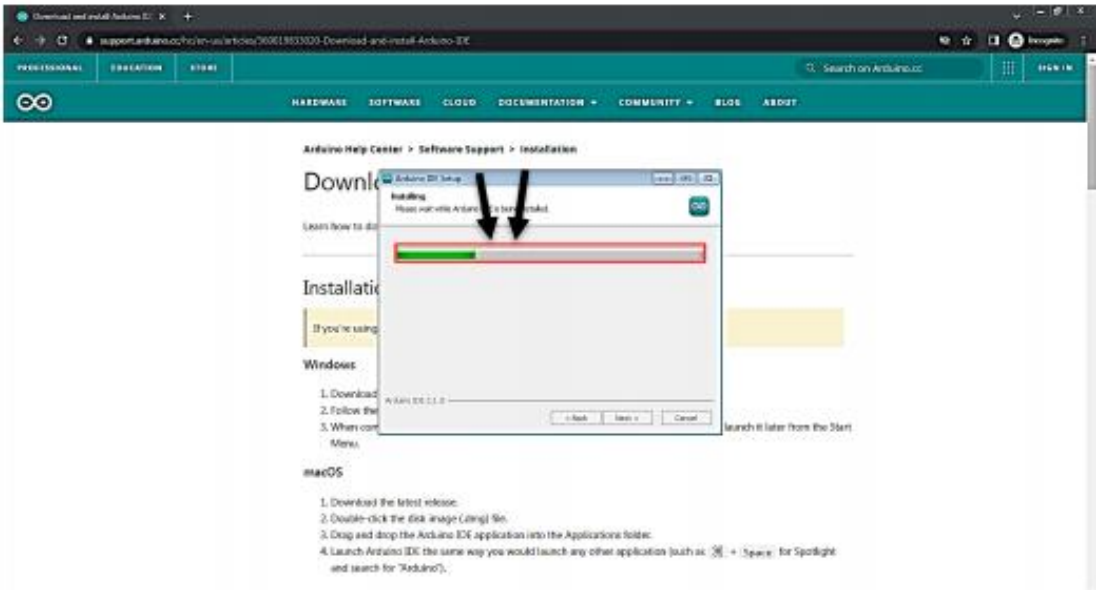
Step 6: Click Agree



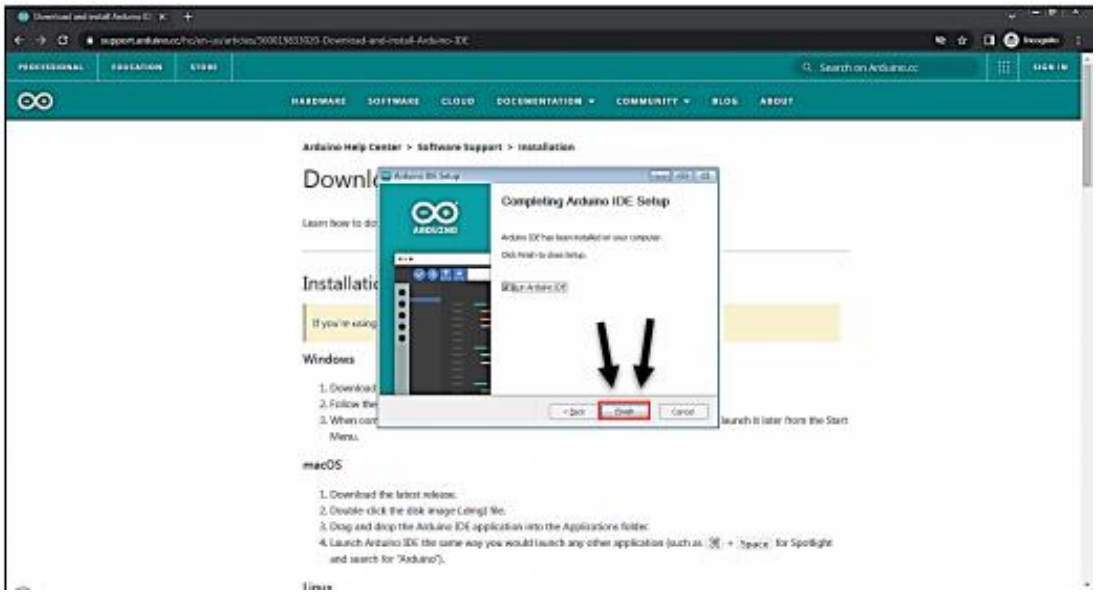
Step 7: Click Install



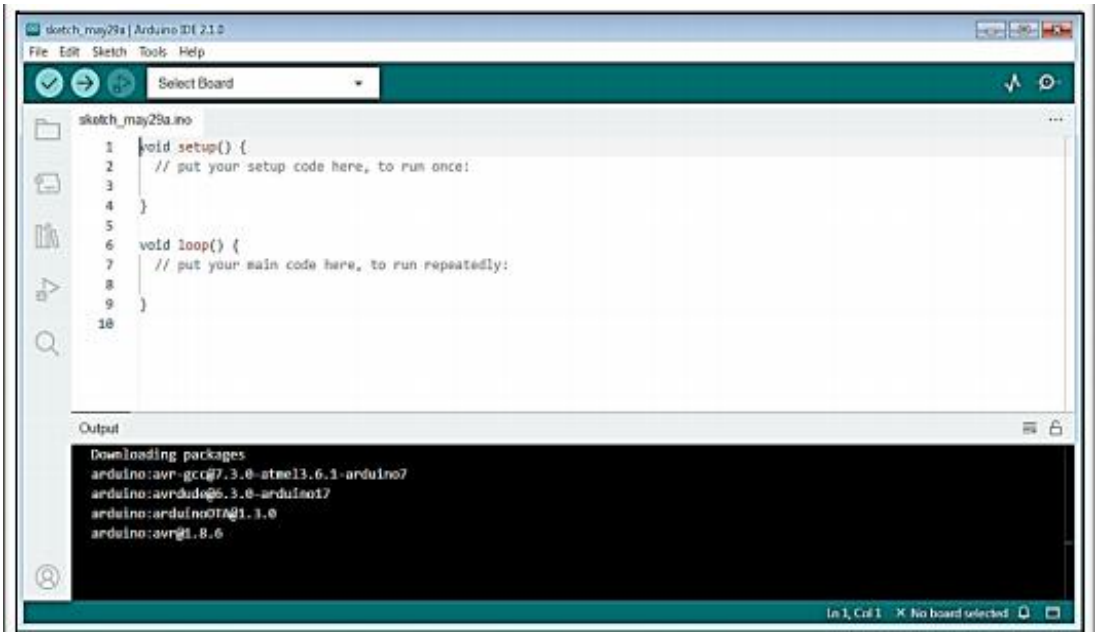
Step 8: Wait until the installation to finish.



Step 9: Click finish. Then you can start your journey on programming the Arduino.

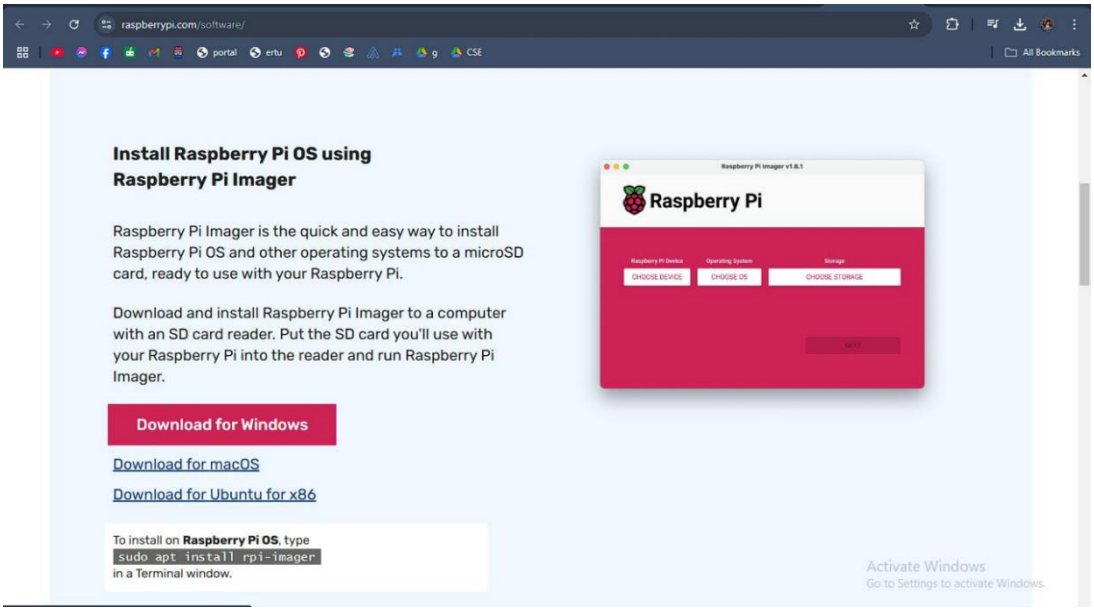


Step 10: Arduino IDE UI

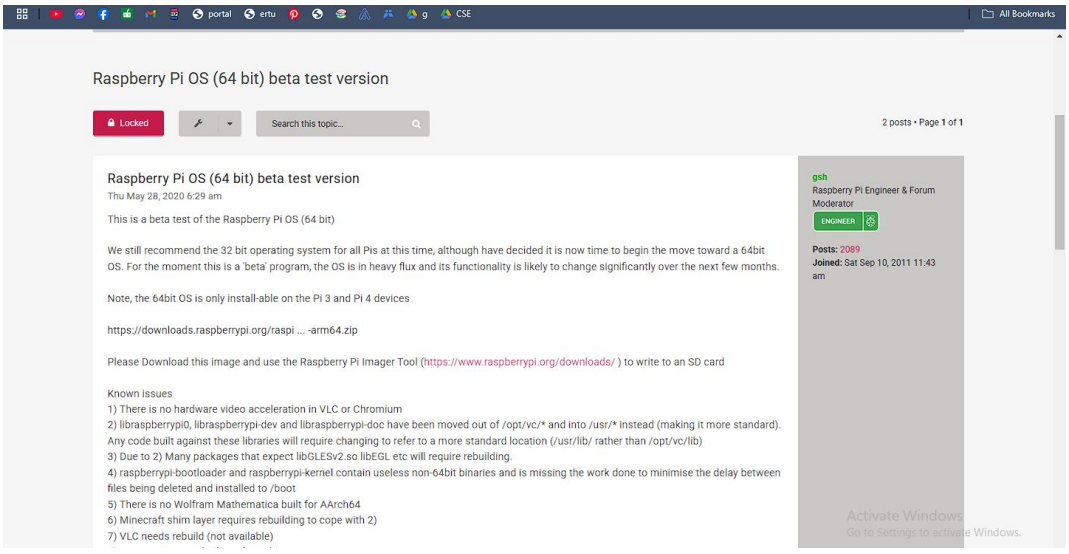


Raspberry PI Installation

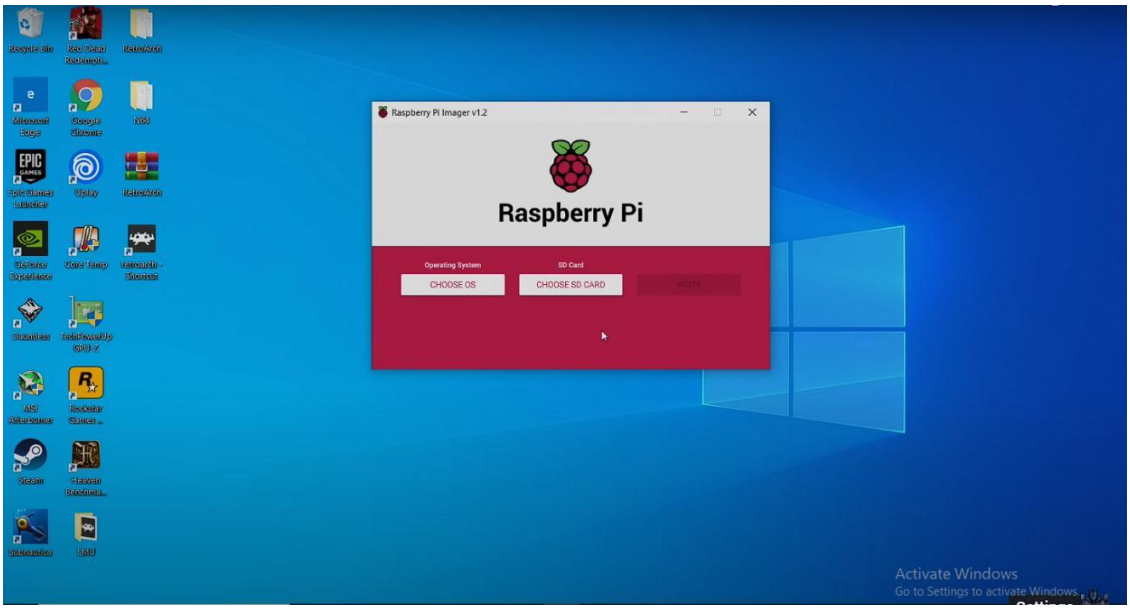
Step 1 Type in the Google search bar “raspberry pi imager”, click the official website, and then click “Download for Windows” to download the Raspberry Pi Imager.



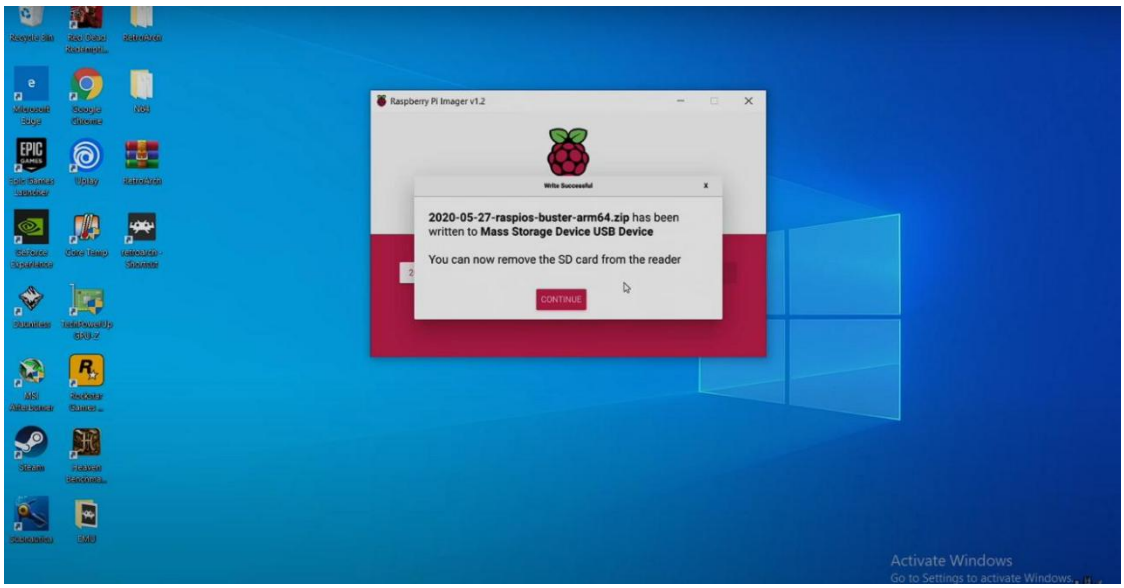
Step 2 Download the OS of Raspberry Pi depending on the model of Raspberry Pi (4)



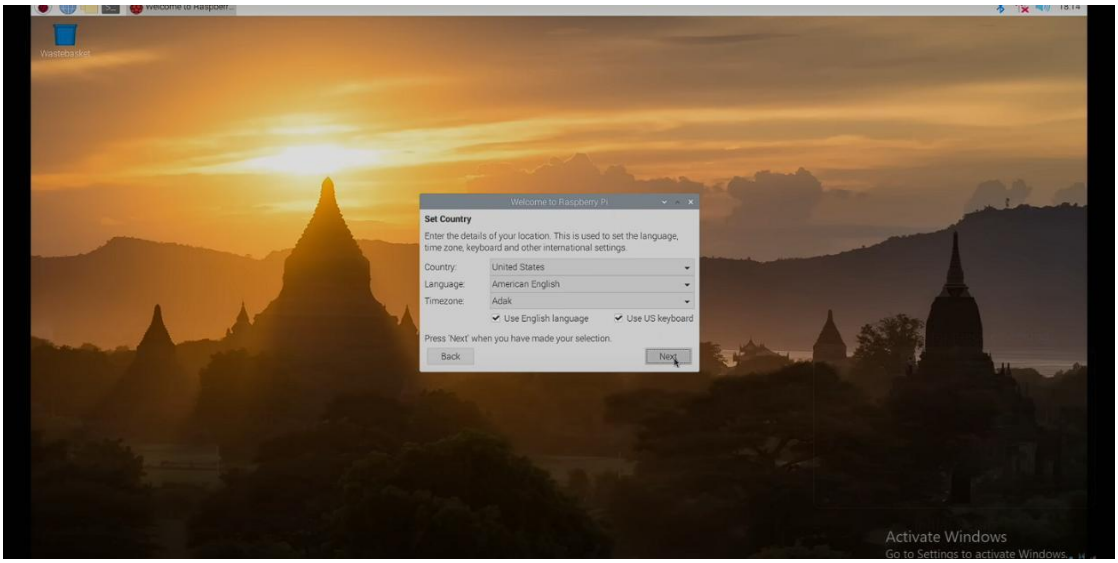
Step 3 To begin writing the operating system to the SD card, insert the downloaded OS and select the SD card of your choice.



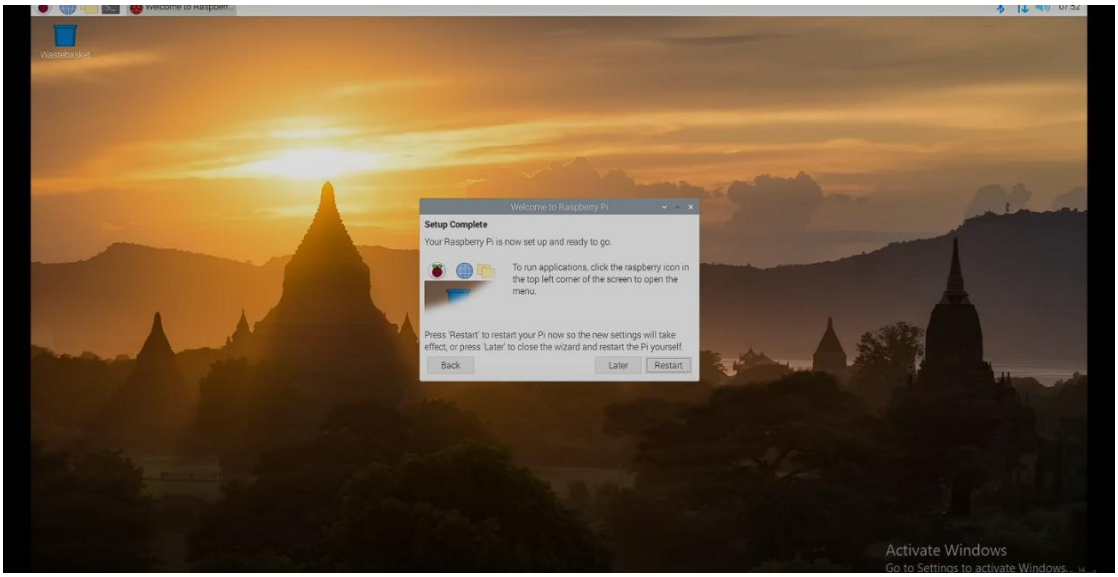
Step 4 After writing is complete, take out your SD card and insert it into your Raspberry P



Step 5 Once the Raspberry Pi is open, enter all the required data, including the password, Wi-Fi, etc.

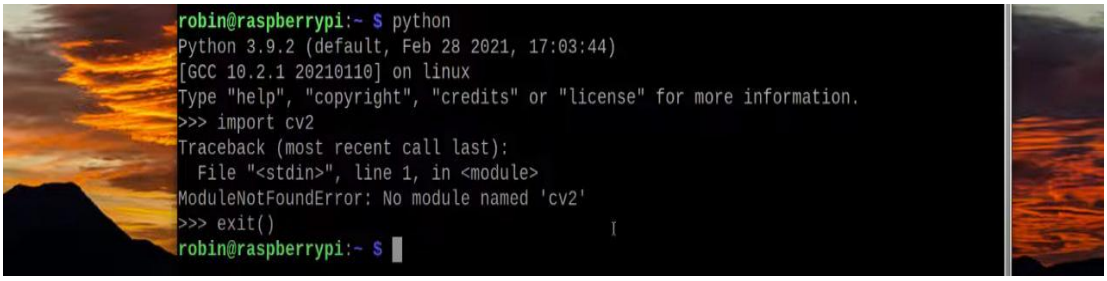


Step 6. Once all the necessary information has been entered, click the "Restart" button to restart the Raspberry Pi, at which point it will be operational.

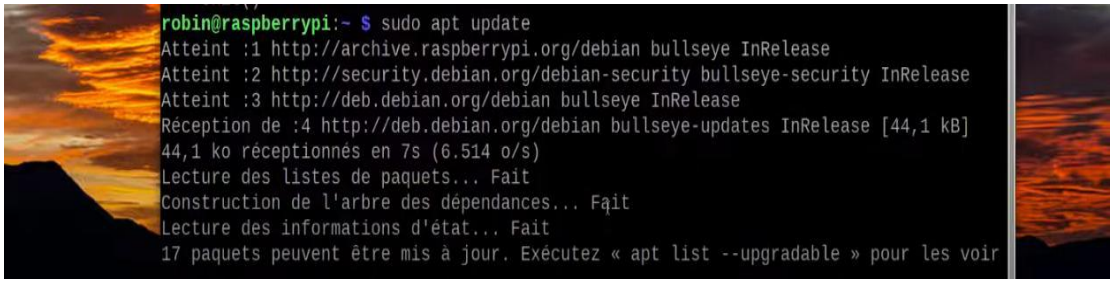


Raspberry Pi OpenCV Installation (WINDOWS)

Step 1 In the Raspberry Pi terminal, type "python" first, followed by " import cv2"to see if OpenCV is already installed.

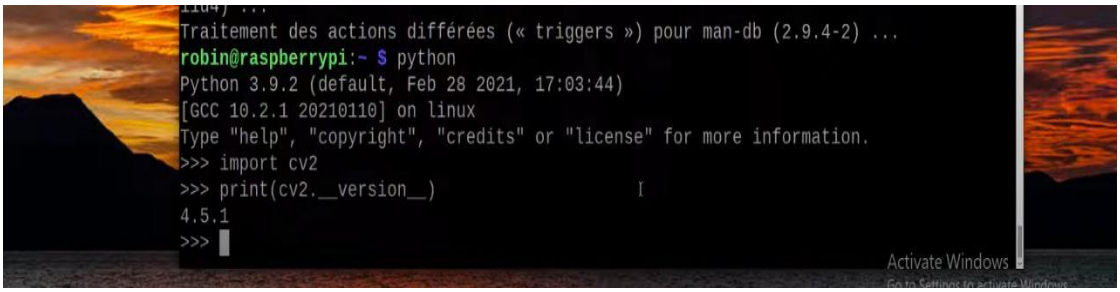


Step 2. Type “sudo apt update” to update the Raspberry Pi.



step 3 After updating type “sudo apt upgrade” to upgrade the OS of Raspberry Pi.

Step 4. Once upgraded, you may install OpenCV by typing "sudo apt install python3- opencv" into the terminal



Step 5 Check to see if the OpenCV installation was successful. After typing "python," write "import cv2." If the OpenCV version appears, the installation of OpenCV was successful.

APPENDIX K

List of Recommendation

RIZAL TECHNOLOGICAL UNIVERSITY – BSCpE Pasig Campus

TITLE :	MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting

Name of Candidate(s)	:	Cabaya, Carlos Anthony C.
		Malubay, Kenneth A.
		Oliveros, Archie Jan E.,
Program	:	Pendre, Dan Joshua, L.
		Tala, Von Anthony B.
Adviser	:	Engr. Ronel D. Paglomutan
Chairman	:	Engr. Ezekiel Nequit
Members	:	Engr, Rizal Laqui
	:	Assoc. Prof. Corazon S. Aspuria
	:	Assoc. Prof. Ma. Felisa A. Molina

LIST OF RECOMMENDATIONS/COMPLIANCE FOR FINAL DEFENSE

MEMBER: Engr, Rizal Laqui

#	RECOMMENDATIONS/SUGGESTIONS	Page(s)	COMPLIANCE	Page(s)
1	Title change	1	MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting	i
2.	Objective of the study edit	20	The objective of the study had been paraphrase	8
3	Significance of the study	24	The farmers had been added	19
4	Chapter II citation	29 - 52	Citation had been Added	25-38
5	Agile Model rearrange	64	The words had been arrange	50-53
6	Add 4.2 3D model with dimensions Add 4.3 3d model with component parts	80	Already been added	62 - 64

MEMBER: Assoc. Prof. Ma. Felisa A. Molina

#	RECOMMENDATIONS/SUGGESTIONS	Page(s)	COMPLIANCE	Page(s)
1	Title change	1	MangoQ: An AI-Based System for Carabao Mango Quality Detection and Sorting	i
2	Fix the table of contents	7	The table of contents had been arrange	i-xii
3	Introduction and back ground of the study citation	13-19	Citation had been added	1 - 4
4	Objective of the study edit	20	The objective of the study had been paraphrase	8
5	IPO mention the data gathering	21	Data gathering had already mention	10
6	Scope and delimitation (remove the title)	22	Title had been removed	17
7	Table 1.1 re-word the weight and size, color	23	Has been Re-word	18
8	Add word " delimitation's"	24	Delimitation's added	17
9	Significance of the study	24	Farmers have been added	19

RIZAL TECHNOLOGICAL UNIVERSITY – BSCpE Pasig Campus

10	Chapter II citation	29 - 52	Citation had been added	25- 38
11	Table 2.1 edit	52	Added unripe category	39
12	Table 2.2 edit	53	Added, large, medium, small	39
13	Table 4.2 edit	102	Results of Component testing	86
14	Table 4.3 edit	103	Result of Carabao mango detection	87
Nothing Follows...				

MEMBER: Assoc . Prof. Corazon S. Aspuria

#	RECOMMENDATIONS/SUGGESTIONS	Page(s)	COMPLIANCE	Page(s)
1	Table of contents Fix	6	The table of contents had been arrange	I-xii
2	IPO Added Software & Hardware on the figure	21	Added software and hardware	10
3	Table 1.1 standard of carabao mango edit	23	The table had been organized	18
4	Agile Model rearrange	64	The words had been arrange	50-53
5	Figure 3.2 add with mobile applications	73	Added mobile applications	59
6	Small the page number font	1-179	10 size font	1 -202
7	Statistical Treatment of data" Represent your formula for percentage in a proper way"	77	Formula for percentage and weighted mean added	59 -60
8	Add 4.2 3D model with dimensions Add 4.3 3d model with label	80	Already been added	62 - 64
9	Remove Pictures on table 4.1 device descriptions	83	hardware requirements image removed	67 - 69
10	Flowchart figure edit	93	Flowchart had been edited	77
11	System Architecture add power source and mobile app	95	Power source and mobile app added to the figure	78
12	Network Architecture add User	96	User added	81
Nothing Follows...				

ADVISER: Engr. Ronel D. Paglomutan

#	RECOMMENDATIONS/SUGGESTIONS	Page(s)	COMPLIANCE	Page(s)
1	Add AI Model and figure	75	AI model & Figure Added	79
2	Add Manual	108	Manual Added	119 - 136
Nothing Follows...				

CHAIRMAN: Engr. Ezekiel Nequit

#	RECOMMENDATIONS/SUGGESTIONS	Page(s)	COMPLIANCE	Page(s)
1	Size citation	6	Ciitation Added	6
2	IPO Discuss each Phase	9	Discussion Added	10 - 16
3	Scope and delimitation add the ability of your system	10	Scope and delimitation system ability added	17 - 19
4	Locale of the study/ add the conducted places	41	Cogeo Public market Added	49

RIZAL TECHNOLOGICAL UNIVERSITY – BSCpE Pasig Campus

5	Component Testing add remarks	46	Remarks Added	54
6	The formula need to be text not picture	52	Formula text format	60
7	Process Flow Diagram discussion	62	Discussion added	70 - 73
8	Schematic Diagram search for example	66	New schematic diagram added	75
9	Concept of operation based on IEEE 1362-1998	70	IEEE 1362-1998 concept added	82
10	Find example for manual	108	Manual added	119 - 136
Nothing Follows...				

RIZAL TECHNOLOGICAL UNIVERSITY – BSCpE Pasig Campus

Noted by;

Engr. Ronel D. Paglomutan
Thesis Adviser
Date:

Reviewed by;

Engr. Rizal C. Iaqui
Subject Adviser
Date:

Approved by;

Engr. Ezekiel Nequit
Chairman
Date:

Prof. Corazon S. Aspuria
Member
Date:

Prof. Felisa A. Molina
Member
Date:

APPENDIX L
Costing and Materials

Name of Parts	Quantity	Price
Expenses For Components		
Arduino UNO R3 (DIP)	1	450.00
MG996R 180 degrees Metal	6	250.00
Servo MG995 12kg 360 Degree HIGH QUALITY	2	250.00
Ultrasonic Ranging Sensor Module	5	49.00
Ultrasonic With Bracket	1	80.00
SG90 Micro 9g Servo Nylon Carbon fiber Gears	1	86.00
DC-DC 24V/12V to 5V 5A Step-down Buck Converter LM2596S	2	75.00
MG996R 180 degrees Plastic	4	170.00
Straight Bar Load Cell Weight Sensor (HX711 + 5Kg)	2	149.00
Raspberry Pi 4B 8gb	1	4500.00
Case Acrylic Black	1	3000.00
Raspberry Pi Camera 3	1	200
Ac/Dc Wall Mnt Adapter	1	7090.00
Flex Cable Csi 15 Pin Ribbon (2 Meter)	1	167.00
Sandisk SDSQXAH 64GB Extreme Micro SD 170MB/S C10	1	402.00
Micro HDMI to HDMI Cable 1.5 meter For Raspberry Pi 4	1	100.00
Octocoupler 5pcs.	2	38.00
Relay 8 channel 5V For Optocoupler	1	127.00
PCB Board Circuit 7x9	3	34.00
Jumper Wire DuPont Wire 10pcs F-M	1	25.00
Jumper Wire DuPont Wire 10pcs F-F	1	25.00
Centralized Power Supply 12V 60W (12V-20A)	1	427.00
Power Wire Side 12V LED Light Connection Extension Line (4	1	230.00
Stikwel Wood 500g	1	130.00
Mighty Bond	1	60.00
Tire wire 1/2	1	50.00
Plywood 1/2	1	825.00
Uno nails 1 1/2	1	50.00
Wood 1 1/2 x 2 x 10	2	190.00
Wood 1 x 1 x 10	3	390.00
Stick Wood	1	20.00
3x3 Wood	1	250.00
Rugby	1	120.00
Thinner	1	70.00
Nails 1 1/2 (Half kg)	1	40.00
Kahoy (Coco Lumber)	4	850.00
Acrylic Transparent 12in x 12in 2mm	1	146.00
Plywood	1	100.00
Pvc pipe 1/2	1	115.00
Soldering Lead 1m	1	20.00
Gear Wheel	18	77.00
Unsealed Bearing 5x16x5	70	65.00
5 mm PLANT STICK SUPPORT MADE OF BAMBOO	50	95.00
SHUNAN Bike Chain 116 Links 10 speed	4	120.00
KDK SYNCHRONOUS MOTOR 5-6R/MINUTE	2	135.00
Rubber Mat	1	160.00
Taiwan Leather	2	130.00
Teeth Breadmaker Conveyor Belts 173 Teeth 8mmx519mm	1	85.00
25mm x 300mm Carboon Steel Conveyor Roller	4	145.00
GT2 Timing Pulleys Pulley 20T / 8mm	2	58.00
Bore Diameter Mounted Bearings Ball Bearing Pillow Block 8m	4	55.00
Potentiometer Single Dual For 3PIN 6PIN (50K-DUAL)	1	25.00
L298N Driver Board Module For High Power L298 DC	1	75.00
Bore Diameter Mounted Bearings Ball Bearing Pillow Block 8m	4	35.00
Welding Carboon Steel Conveyor Roller		

Stepper Motor Nema 17 3000g-cm	1	700.00
Hex Nut M4 x 0.7	50	40.00
Hex Nut M3 x 0.5	50	40.00
RoundHead M4 x 20MM	50	40.00
RoundHead M3 x 20MM	50	40.00
3.94 FT Gear Chain for Automatic Incubator Egg Turner	1	100.00
Servo Shield	2	250.00
MG996R 180 degrees Metal	4	250.00
Carabao Mango	25	1000.00
Resistor 1k Ohms	5	25.00
Resistor 2.2k Ohms	5	50.00
Resistor 5k Ohms	5	50.00
Prototype Lalamove	4	2000.00
Switch	6	25.00
1/4 illustration board	5	40.00
Net	1	120.00
Liha	10	30.00
Liston Wood	2	120.00
Servo Arm Metal 1 Horn	2	63.00
Servo Arm Metal 2 Horn	5	80.00
Black Screw	20	5.00
Hook Screw	20	10.00

Expenses Design 2 Prototype	
Singil	
1,500.00	
1,000.00	
1,500.00	
600.00	
300.00	
1,000.00	
Name	Payment
Cabaya	5900.00
Oliveros	5900.00
Tala	5900.00
Pendre	5900.00
Malubay	5900.00
Total Contribute	29500.00

APPENDIX M

Source Code

RPI CODE

```
import cv2
import cvzone
import pyrebase
import serial
import torch
from picamera2 import Picamera2
from libcamera import controls
from time import sleep


picam2 = Picamera2()
picam2.preview_configuration.main.size = (480, 640)
picam2.preview_configuration.align()
picam2.configure("preview")
picam2.set_controls({"AfMode": controls.AfModeEnum.Continuous})
picam2.start()


model = torch.hub.load("ultralytics/yolov5", "custom", path="bestv5s.pt")
model.conf = 0.4
class_list = model.names
count = 0


config = {
```

```
 "apiKey": "AIzaSyASOzEC6YbY161o19yiHaknmsV1ECE8RX4",
 "authDomain": "mango-database-e8657.firebaseapp.com",
              "databaseURL": "https://mango-database-e8657-default-rtdb.asia-
  southeast1.firebasedatabase.app",
"projectId": "mango-database-e8657",
"storageBucket": "mango-database-e8657.appspot.com",
 "messagingSenderId": "190857298549",
 "appId": "1:190857298549:web:3c6943032c4c46a009ae3c",
  "measurementId": "G-N8WGZKYWNQ",
  }
  firebase = pyrebase.initialize_app(config)
  db = firebase.database()
  mango_class_list = []
  mango_size_list = []
  ser = serial.Serial("/dev/ttyACM0", "115200")  # type: ignore
  sleep(2)
  def insertData(class_dir, size_dir=None):
  total = int(db.child(f"{class_dir}/overall/total").get().val())  type: ignore
 totaldata = int(db.child("dtmango/total").get().val())  # type: ignore
 if class_dir != "decay":
  size = int(db.child(f"{class_dir}/overall/{size_dir}").get().val()) type: ignore
 data = {
"no": totaldata + 1,
```

```
  "qty": f"{class_dir.capitalize()}",
"qtyper": 0.57,
"size": f"{size_dir.capitalize()}",
 "weight": 50,
            }
            db.child(f"dtmango/data/data{totaldata + 1}").set(data)
            db.child("dtmango").update(
               {
                  "total": totaldata + 1,
               }
            )
   updates = {
     **({f"{size_dir}": size + 1} if class_dir != "decay" else {}),"total": total + 1,
      }
   db.child(f"{class_dir}/overall").update(updates)
   def weight2size(weight):
  if weight >= 30:
  size = "large"
  elif weight >= 20:
  size = "medium"
   elif weight >= 10:
   size = "small"
   return size
```

```
def mangodetect(mango_class, mango_size):
if mango_class == "ripe":
ser.write("ripe-servo".encode())
elif mango_class == "raw":
ser.write("raw-servo".encode())
if mango_size == "large":
    ser.write("large-servo".encode())
    elif mango_size == "medium":
    ser.write("medium-servo".encode())
    elif mango_size == "small":
    ser.write("small-servo".encode())
    insertData(mango_class, mango_size)
    mango_class_list.clear()
    mango_size_list.clear()
    getWeight()
def getWeight():
    while True:
  # userinput = input("input weight: ")
    # weight = int(userinput)
    weight = 10
    if weight > 0:
    mango_size_list.append(weight)
    if len(mango_size_list) == 3:
```

```
    ser.write("weight-servo".encode())
    getClass()
    break
    sleep(1)
def getClass():
   sleep(3)
  while True:
  im = picam2.capture_array()
  im = cv2.cvtColor(im, cv2.COLOR_BGR2RGB)
  im = cv2.rotate(im, cv2.ROTATE_90_CLOCKWISE)
  count += 1
  if count % 3 != 0:
  continue
  im = cv2.flip(im, -1)
  results = model(im)
  for det in results.xyxy[0]:
  x1, y1, x2, y2, conf, d = det.tolist()
   c = class_list[int(d)]
  if len(mango_class_list) != 5:
  mango_class_list.append(c)
  else:
  ser.write("flip-servo".encode())
  if "decay" in mango_class_list:
```

```
insertData("decay")
mango_class_list.clear()
mango_size_list.clear()
getWeight()
break
else:
mangodetect(max(set(mango_class_list), key=mango_class_list.count),
   weight2size(mango_size_list[-1]),
 )
 break
cv2.rectangle(im, (int(x1), int(y1)), (int(x2), int(y2)), (0, 0, 255), 2)
            cvzone.putTextRect(im, f"{c} {conf:.2f}", (int(x1), int(y1)), 1, 1)
print(f"{c} {conf:.2f}")
cv2.imshow("Camera", im)
if cv2.waitKey(1) == ord("q"):
break
   cv2.destroyAllWindows()
    ser.write("feeder-servo".encode())
   getWeight()
```

Arduino Code

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
// #include <Stepper.h>
#include "HX711.h"

// const int stepsPerRevolution = 200;
const int Dout_Pin = 2;
const int SCK_Pin = 3;

HX711 scale;
// Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();
#define SERVOMIN  150 // Pulse Length 90 degrees
#define SERVOMAX  600 // Pulse Length 160 degrees
float calibration_factor = 1000;
float weight_threshold = 10.0;

void setup() {
  // set speed rpm
  // myStepper.setSpeed(75);
  Serial.begin(9600);
```

```
    scale.begin(Dout_Pin, SCK_Pin);


    pwm.begin();
    pwm.setPWMFreq(60); // Set PWM frequency for servos


    // Set the scale factor
    scale.set_scale(calibration_factor);
  }


  void loop() {
    // Set one direction for the stepper motor
    // myStepper.step(stepsPerRevolution);


    if (scale.is_ready()) {
      scale.tare();
      delay(1000);


      long reading = scale.get_units(10);
      Serial.println(reading); // Send the output to python


      if (reading > weight_threshold) {
 int weight_servo = map(reading, weight_threshold, weight_threshold + 100, SERVOMIN,
SERVOMAX);
```

```
      weight_servo = constrain(weight_servo, SERVOMIN, SERVOMAX);
      pwm.setPWM(0, 0, weight_servo); // Move servo
    } else {
      // No weight detected, set servo to 90 degrees
      pwm.setPWM(0, 0, SERVOMIN);
  } else {
    Serial.println("HX711 not read");
  }
  delay (500);
  // // Control the servo using the Adafruit_PWMServoDriver object
  // for (uint16_t pulselen = SERVOMIN; pulselen < SERVOMAX; pulselen++) {
  //   pwm.setPWM(0, 0, pulselen);  // Move servo
  //   delay(10);
  // }
  // for (uint16_t pulselen = SERVOMAX; pulselen > SERVOMIN; pulselen--) {
  //   pwm.setPWM(0, 0, pulselen);  // Move servo
  //   delay(10);
  // }
}
```

APPENDIX N

Curriculum Vitae

Cabaya, Carlos Anthony C.

109 Sitio Pinagpala Angono, Rizal

09095434317

2020-202718@rtu.edu.ph

PERSONAL INFORMATION

Age : 23

Gender : Male

Birthdate : 05/24/2001

Religion : Catholic

Civil Status : Single

Citizenship: Filipino

EDUCATIONAL BACKGROUND

Primary : Joaquin Guido Elementary School Angono, Rizal
S.Y 2006 - 2012

Lower Secondary: Christ The King College of Angono, Rizal
S.Y 2012 - 2017

Upper Secondary: Trent Information First TCI Taytay, Rizal
S.Y 2017 - 2019

Tertiary : Rizal Technological University Pasig Campus
S.Y 2020 – Present

Malubay, Keneth A.

Purok 3 Zone 6 Penafrancia Antipolo Rizal

09501527600

2020-208622@rtu.edu.ph

PERSONAL INFORMATION

Age : 22

Gender : Male

Birthdate : 12/05/2001

Religion : Christian

Civil Status : Single

Citizenship: Filipino

EDUCATIONAL BACKGROUND

Primary : Kabisig Elementary School

S.Y 2008 - 2014

Secondary : Francisco P. Felix Memorial National High School

S.Y 2014 – 2018

: ABE International Business School

S.Y 2018 – 2020

Tertiary : Rizal Technological University - Pasig Campus

S.Y 2020 - Present

Oliveros, Archie Jan E.

Blk. 1 Banana St. Pinesville Subd. Dolores

Taytay Rizal

09765427734

2020-202100@rtu.edu.ph

PERSONAL INFORMATION

Age : 22 **Religion** : Roman Catholic

Gender : Male **Civil Status** : Single

Birthdate : 01/24/2002 **Citizenship** : Filipino

EDUCATIONAL BACKGROUND

Primary : De Castro Elementary School
S.Y 2006 - 2012

Secondary : Sta. Lucia High School
S.Y 2012 - 2017

Tertiary : Rizal Technological University Pasig Campus
S.Y 2020 – Present

Pendre, Dan Joshua

106 JM Basa St., Calumpang, Marikina City

09198780857

2020-202108@rtu.edu.ph

PERSONAL INFORMATION

Age : 23 **Religion** : Catholic

Gender : Male **Civil Status** : Single

Birthdate : 07/14/2001 **Citizenship** : Filipino

EDUCATIONAL BACKGROUND

Primary : San Roque Elementary School
S.Y 2008 - 2014

Secondary : San Roque National High School
S.Y 2014 - 2020

Tertiary : Rizal Technological University - Pasig Campus
S.Y 2020 - Present

Tala, Von Anthony B.

Blk 24 Road 37 Damayan San Juan Taytay, Rizal

09208998138

2020-200383@rtu.edu.ph

PERSONAL INFORMATION

Age : 22 **Religion** : Catholic

Gender : Male **Civil Status** : Single

Birthdate : 03/22/2002 **Citizenship**: Filipino

EDUCATIONAL BACKGROUND

Primary : Ems Signal Village elementary school

S.Y 2008 - 2010

: Bagong Pag-asa Elementary School

SY: 2010 – 2014

Secondary : Rizal Experimental Station and Pilot School

Of Cottage Industries

S.Y 2014 - 2020

Tertiary : Rizal Technological University - Pasig Campus

S.Y 2020 - Present