Minimizing Post-Harvest Losses Through the Implementation of an Early Determine Fruits Freshness.

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Contents

Abstract

Post-harvest loss is a significant issue in the agriculture industry. The freshness of the fruits and the detection of fruit spoilage is the focus of this project. This system includes the provision of an expert tool for detecting fruits freshness and fruit spoilage. This tool can be used in the farming process to determine the status of client requests as Commercial sells. The aims presented in this tool using matching learning, are to provide expertise in implementing fruits freshness detection techniques. Post- harvest loss includes the loss of fruits across the fruits supply chain from the harvesting of crops until This tool can offer several benefits, such as enhancing fruits quality and safety, extending shelf life, reducing waste, and improving customer satisfaction. Every day, 25,000 Mt of vegetables and fruits are wasted in different economic centers. In Sri Lanka post-harvest wastage exterminating in the loss of 12 metric tons of produce daily at Dambulla economic center. In handling, storing, and distributing produce after harvest, half of the fruits and vegetables are lost. This research aims to prove a system that can assess the quality and freshness of selected fruits for papaya and banana local name (Ambul) /common name (Sour Banana). We need to categorize the fruits into two groups as green and yellow, and test them on four selected days, the day of harvest, three days after harvest, one week after, to observe the changes in these four factors (methane, temperature, humidity, and texture). After entering the type of fruit in methane, temperature, humidity, and texture after 45 minutes as inputs for the model, the model will predict the freshness of the fruit as a percentage. The quality of the fruits is monitored for early detection of freshness under different environmental using parameters such as gas (methane), firmness, temperature and humidity of fruits. A Software algorithm analyses sensor data to determine freshness evaluating fruits quality through IOT based solution. The collected data were used to train the machine learning model (CNN). By entering values of methane as inputs, the model predicts the freshness of the fruit and its ripeness stage. Monitoring fruits quality through early detection helps improve supply chain efficiency and ensuring customer satisfaction. By early identification of the freshness and ripeness of fruits, the sellers can give some discount and profit the same fruit for other diversified products, its helps in reducing post-harvest damage. This innovative solution can minimize the critical issue in the post-harvest wastage. To get accurate results, it is advised to employ sensors with greater sensitivity.

Acknowledgment

I had to enlist the assistance and counsel of a few well-respected individuals to complete my project. Special thank go to my project supervisor, Dr. Ajith Madurapperuma . And I am also grateful to our guide Mrs. Maduwanthi Uthpala and Mr Dhishan Dhammearatchi for their support and time throughout this entire project. I’d also like to express my gratitude to everyone who has helped me write this project, both directly and indirectly. Many people, particularly my classmates, have provided helpful feedback on my work, which has inspired me to increase the quality of this project.

Chapter 01

Introduction

"Post-harvest loss" refers to food loss that occurs across the entire food supply chain, from crop harvesting to final crop consumption. All the energy and water needed for food production, harvesting, transportation, and packaging are also wasted when food is discarded 50% of fruits and vegetables are lost in postharvest handling, storage and distribution. Crops are grown in 5 districts as mainly Kurunegala, Monaragala, Rathnapura, Kaluthara, Badulla among them Kurunagala and Rathnapura cultivates banana as grants. Losses during the harvesting phase are1-5%, and mechanical threshing also results in losses of one to five percent. Small percentages of material are lost during mechanical drying and sealed storage. However, post-harvest losses are primarily caused by the commercial milling process, with losses ranging from 5 to 30%. Two of the numerous elements that contribute to these losses include insects, which account for 10.4% of the losses, and weather conditions, which account for 24.6% of the losses.

Inadequate management and livestock lead to 13.4% and 17.9% of losses, respectively; illness accounts for 14.2%, and inadequate harvesting techniques for 6.0%. In this research, it was deemed necessary to develop a system that can assess the quality and freshness of selected fruits. In this research can early detection of spoilage in different environmental conditions using parameters like gas (methane), firmness, color, temperature, and humidity. These parameters can be used to evaluate fruit quality through an IoT-based solution ..(J.Srinidhi, et al., July 2022)

1.1Background

About 21 million people, or 70% of the country's total population, reside in non-urban areas, with 40% of them making their living from agriculture. For fruits, these losses are estimated to be between 30% and 40%, and for vegetables, between 20% and 40%. All the water and energy needed for food production, harvesting, transportation, and packaging are also squandered when food is thrown away. Moreover, food waste decomposes in landfills and releases methane, an even more potent greenhouse gas than carbon dioxide.

percentage of all food produced, with around one-third of the world's food output wasted or lost each year when quantity is compromised. This results in a decrease in the availability of food, higher food costs, and a decrease in farmers' revenue. According to post-harvest loss estimates, the Dambulla economic center in Sri Lanka lost between 12 and 15 million tons of produce every day. Every day, 25,000 Mt of vegetables and fruits are wasted nationwide in different economic centers. In handling, storing, and distributing produce after harvest, half of the fruits and vegetables are lost.

1.2Aims of the project

In this research deemed necessary to prove a system that can assess the quality and freshness of selected fruits. The quality of the fruits monitored to by the early detection of spoilage in different environmental conditions by using these parameters such as gas (methane), firmness, color, temperature and humidity of fruits.

1.3.1 Academic Questions and Objective

Academic Questions

- How do sensors detect various data to detect freshness using these parameters such as color, texture, smell, temperature and humidity?
- How does software algorithm analyses sensors data to determine freshness?
- How to determine and sells at the right times for fruits?

1.3.2 Objectives

- have to undertake primary and secondary researches to gather reviews of growers, retailers and customers
- Implement a spoilage detection system identification the freshness of the fruits and spoiled fruits.
- Determine the right time to harvest and sell vegetables and fruits.
- Compare feedback from growers, retailers, sellers and customers.

1.4 Scope

The scopes that are represented in this system include the provision of an expert tool for the detection of freshness and spoilage. This tool can be used in farming process to determine the status of client requests for Commercial sells. The aims of this tool using matching learning are to provide expertise in implementing fruits freshness detection techniques. Post- harvest loss includes the loss of fruits across the fruits supply chain from the harvesting of crops until their consumption then this tool can offer several benefits, such as enhancing fruits quality and safety, extending shelf life, reducing waste, and improving customer satisfaction. The primary goals of the study are to create a method for determining how fresh fruit is and identifying spoilage. This method will identify and gathering data from using detection parameters at the appropriate moment, thereby determining the fruits' freshness and accomplishing the project's goals.

1.5 Structure of the Report

The report's introduction, which covers the project and its contents. The goals, and academic questions and objectives are covered in chapter 01 of the project report. It evaluates how fresh produce and fruits are. This project employed the DHT11 Temperature and Relative Humidity sensor and the Methane gas sensor MQ-4 to indicate the temperature, humidity, and release of methane after harvesting primarily fruits and vegetables. The goals are to identify and determine fresh fruits by implementing a spoilage detection system. Fruit quality is evaluated using selected parameters including gas (methane), firmness, color, temperature, and humidity to detect rotting early in various environmental circumstances. And use an IOT-based system is used to assess the quality of the fruits. (J.Srinidhi, et al., July 2022)

The focus of the literature review in chapter 02, which includes related initiatives. Certain researchers have developed a more effective way for identifying damaged food than more expensive ones. The Arduino UNO prototyping board is employed in this system, and an ESP8266 acts as a bridge to connect the Arduino to the internet.

Chapter 3 covers by planning, methodology, and feasibility studies, including this project. Those a timetable, legality, operational, financial, and technical viability. This includes project is part of the methodology. The work breakdown structure for the project work plan is discussed. The analysis section covers the project's requirements. It has including primary and secondary data collection techniques. Interface, architecture, and physical schematics were covered in the designing section. Unit testing, integration testing, and system testing are covered in the implementation section and including how the system was constructed utilizing component and deployment diagrams.

Chapter 04 covers test cases that provide evidence of the relevant area in relation to the project's implementation, all of which are highlighted and described in detail.

The major project findings that could not be described in detail are covered in chapter 05 in a general fashion. Specific findings that are significant to the scientific community are critically evaluated and debated, along with potential future extensions.

Chapter02:
Literature Review

Post-harvest food loss is characterized by a measurable decrease in either the quantity or quality of food once it has been harvested. This reduction can represent a significant proportion of the total food produced, this project utilizes fruit freshness and the ability to detect fruit deterioration. This system includes a fruit freshness and an expert fruit deterioration. In the farming process, this tool can be used to find out how client requests are progressing as commercial sells. The tool's machine learning goals are intended to impart knowledge on how to apply methods for detecting the freshness of fruits.

These losses pose a threat to food security, nutrition, and income for many households. When quantity is compromised, it diminishes the food supply, leads to elevated food prices, and reduces the income of farmers, particularly when the produce is intended for household consumption rather than sale. On the other hand, quality losses result in food being less nutritious or potentially hazardous to health. Post-harvest loss encompassing food loss throughout the food supply chain from crop harvesting to consumption, has significant environmental impacts. It adversely affects the environment in the following ways such as resource waste, greenhouse gas emissions, air pollution. (Mutungi, 2022)

In this research deemed necessary to prove a system that can assessment of the quality and freshness of food items. The quality of the food should be monitored to prevent spoilage in different environmental conditions such as temperature, humidity of vegetables and fruits. These can be evaluating food quality through various techniques. Food freshness tool with using spoilage detector is to identify the gases emitted by spoiled food and notify the user of the food's spoilage. (J.Srinidhi, et al., July 2022,)
In this research paper, Denise Wilson examines the quality of fruit in farm-to-table businesses from the time of harvest until consumption. The methods for quantifying ethylene gas, acidity (pH), and sweetness (sugar concentration) are mentioned (Wilson, 2021)

In this researchers have a more efficient approach to identify spoiled food as compared to the expensive methods. In this system used the prototyping board Arduino UNO is utilized, and an ESP8266 serves as the intermediary for connecting the Arduino to the internet. Arduino and ESP8266 are controlled via Wi-Fi modem. An LCD panel is integrated into the system to display the sensor's output. It linked to the Arduino board. (Mishra, April-2022)

Measure the freshness of fruits by observing their CO2 release, and O2 absorption after harvesting for papaya and watermelon. It categorized into three groups (500g-1kg, 1kg-1.5kg, 1.5kg-2kg) and were tested on four selected days, including the harvested day, three days after harvest, a week after, and two weeks after, in order to observe changes in these three factors (CO2, O2, and humidity). Changes were detected using a CO2 sensor, an O2 sensor, and a humidity sensor that had been set up for detecting these changes. (P.K.S.C.Jayasinghe, 2022) Development of textural changes on the surface of the crop and others that use a non-destructive approach and can in some cases measure and sense ripeness over time and even in real time in determining the level of ripeness of the fruit or vegetable. (Cortez, 2018)

Classifying and identifying fresh fruits is part of the supply chain for fresh fruit. Meanwhile, deterioration and waste occur throughout the distribution and transportation of fresh fruit. Such drawbacks in this scenario can be prevented by employing technology to continuously monitor fresh fruit.
This can be resolved by employing smart logistics to monitor during the transaction process. The primary goal of the effort was to reduce or minimize waste. The ability to detect the freshness of fruits and vegetables can help consumers purchase nutritious and tasty produce, enhance diet quality, and ensure that the food and agriculture sectors produce high-quality goods that satisfy consumer demands while growing their market share and sales. Currently, method for determining the freshness of fruits and vegetables is manual observation and judgment. This method has the drawbacks of subjectivity and low accuracy, and it is not always possible to satisfy the demands of large-scale, quick, and high-efficiency detection. The issue of limited adaptation of artificially generated features remains, which results in low effectiveness of large-scale detection of vegetable and fruit freshness, although some research showing that this can be done. (Yuan, 2024) This study measured the gasses produced from solid food and used sensors to assess the pH of liquid food to construct an affordable, user-friendly micro-system to determine whether

or not food is rotting. And use wireless connection to send the data. One research mansion that is liquid is monitored with a pH sensor, while food that is solid is monitored with a MQ-4 gas sensor. (Dr G. Sandhya Devia, 2023)

Convolutional Neural Network (CNN) model to identify the kind of vegetables and fruit. After that, the proposed system uses sensors and actuators to measure the degree of food degradation while keeping an eye on the temperature, humidity, and gas emission levels of fruits and vegetables. In addition, this would regulate the atmosphere and prevent food rotting wherever feasible. A message alerting the customer to the degree of food spoilage is also delivered to their registered cell numbers, depending on how fresh. (Ekta sonwan, 2021)

Fruits, dairy products, and other home food items can all have their freshness determined by a smart system. The determination and choice of a gas, moisture, and hydrogen sensor using a sensor, a sensible food freshness detector can determine if food is fresh and advise on whether to consume it or throw it out.
To show the outcomes of the food items that the gadget has checked, a web application has been developed. (Suruchi Parmar1, 2020)

Introduction

After food is harvested, there is a discernible drop in both quantity and quality, which is known as post-harvest fruit loss. Considering that around one-third of the world's food output is lost or wasted every year, this reduction can account for a sizeable fraction of the overall amount produced. The income, nutrition, and food security of many people are at risk due to these losses. A compromised quantity limits the amount of food available, drives up food prices, and lowers farmers' income especially if the product is meant for family use rather than commercial sales. Conversely, post-harvest lost quality becomes less nutrient-dense or even dangerous for consumption. Significant environmental effects result from post-harvest loss, which includes food loss from agricultural harvesting to consumer consumption along the food supply chain. The following are some of the ways that it negatively impacts the environment: air pollution, greenhouse gas emissions, and resource waste.

This causes the market prices to drop, farmers' earnings to decline, and the supply of safe. (Christopher Mutungi, 2022) Fruit that is meant to be consumed fresh only is referred to as fresh fruit. It travels along the usual routes for distributing fresh fruit. The Board may from time to time provide further, more detailed definitions that do not conflict with this definition.
It is thought vital to demonstrate a system that can evaluate the freshness and quality of food items. To avoid food spoiling in various climatic circumstances, such as temperature and humidity for fruits and vegetables, food quality should be regularly checked. Food quality can be assessed using a variety of methods. The sensor determines the food's quality. That and the observation of color

variations. a few signal processing methods. Using sensors, some pattern recognition is used to detect when fruit is served. (J.Srinidhi, et al., July 2022,)

In order to determine freshness, this study monitors methane levels in fruit in addition to temperature and humidity. Furthermore, methane is usually produced during the fruit's post-harvest breakdown. A gas sensor that can identify tiny amounts of methane. In handling, storing, and distributing produce after harvest, half of the fruits and vegetables are lost. In this research deemed necessary to prove a system that can assessment of the quality and freshness of selected fruits. The quality of the fruits monitored to by early detection spoilage in different environmental conditions by using these parameters such as gas (methane), firmness, color, temperature and humidity of fruits. Software algorithm analyses sensors data to determine freshness and these can be evaluating fruits quality through IOT based solution. The quality of the fruits monitored to by early detection help for improving supply chain efficiency and ensuring customer satisfaction. By this innovative solution that can be minimize critical issue in the post-harvest wastage.

Similar project

Compared to costly procedures, this research's method of identifying damaged food is more effective. The Arduino UNO prototyping board is employed in this system, and an ESP8266 acts as a bridge to connect the Arduino to the internet. A Wi-Fi modem is used to control both Arduino and ESP8266. The system incorporates an LCD panel to show the output from the sensor. It is connected to the Arduino board. (Mishra, April-2022)

When papaya and watermelon are harvested, their CO2 release and O2 absorption release and O2 absorption are observed to determine how fresh they are. In order to track changes in these three variables (CO2, O2, and humidity), they were divided into three groups (500g-1kg, 1kg-1.5kg, and 1.5kg-2kg) and evaluated on four specific days, including the harvest day, three days following harvest, one week after, and two weeks after. CO2, an O2, and humidity sensors that had been configured to detect these changes were used to find alterations. (P.K.S.C. Jayasinghe, 2022)

Source	Author	CO_2 Sensor	O2	PH	Humidity	Temperature	color	firmness	Display freshness of fruits	Spoilage Detection	calculate the time taken to ripen a fruits
Detection of Freshness of the Fruits using Machine	P.K.S.C. Jayasinghe1* and S.	x	x		x				x		

Learning Techniques	Sammani 1										
IOT Based Food Spoilage Detection System using Arduino	J.Srinidhi , M.Nakshatra, P.Kavya, M.Ravi kuma	x								x	
IEEE Determination of the level of ripeness and freshness of fruits by electronic sensors.	Cortez, Omar Otoniel Flores	x	x						x		
Review of Post-Harvest Losses of Fruits and Vegetables	Yahaya SM* and Mardiyya AY				x	x					x
FOOD SPOILAGE DETECTION SYSTEM	Simant Mishra*1 , Chandu Surya Prakash Naidu*2	x								x	
Food Spoilage Detection Using IoT	Dr G. Sandhya , Dr G. Suvarna Kumar P. Sree Lahari	x		x						x	
An Artificial Intelligence Approach Toward Food Spoilage Detection and Analysis	Ekta sonwan, Abdullah M. Baqasah, Roobaea Alroobaea,Mustapha Hedabou	x			x	x				x	

An Efficient System to Detect Freshness and Quality of Food	Suruchi Parmar1, Tejaswini Manke2, Neha Badhan3, Prasad Borase4, Prof. N.S.Ujgare5	x							x		
Chemical Sensors for Farm-to-Table Monitoring of Fruit Quality	Denise wilson			x			x	x	x		
DETECTION OF FRESH/ROTTEN FRUITS USING MACHINE LEARNING	Ms. Monica Gunjal, Ms. Gayatri Londhe, Ms. Amruta Thorat, Vipul Roy, Rahul Singh, Vibhavari Borole								x		
My project		x			x	x	x	x	x	x	x

Chapter 03

Methodology

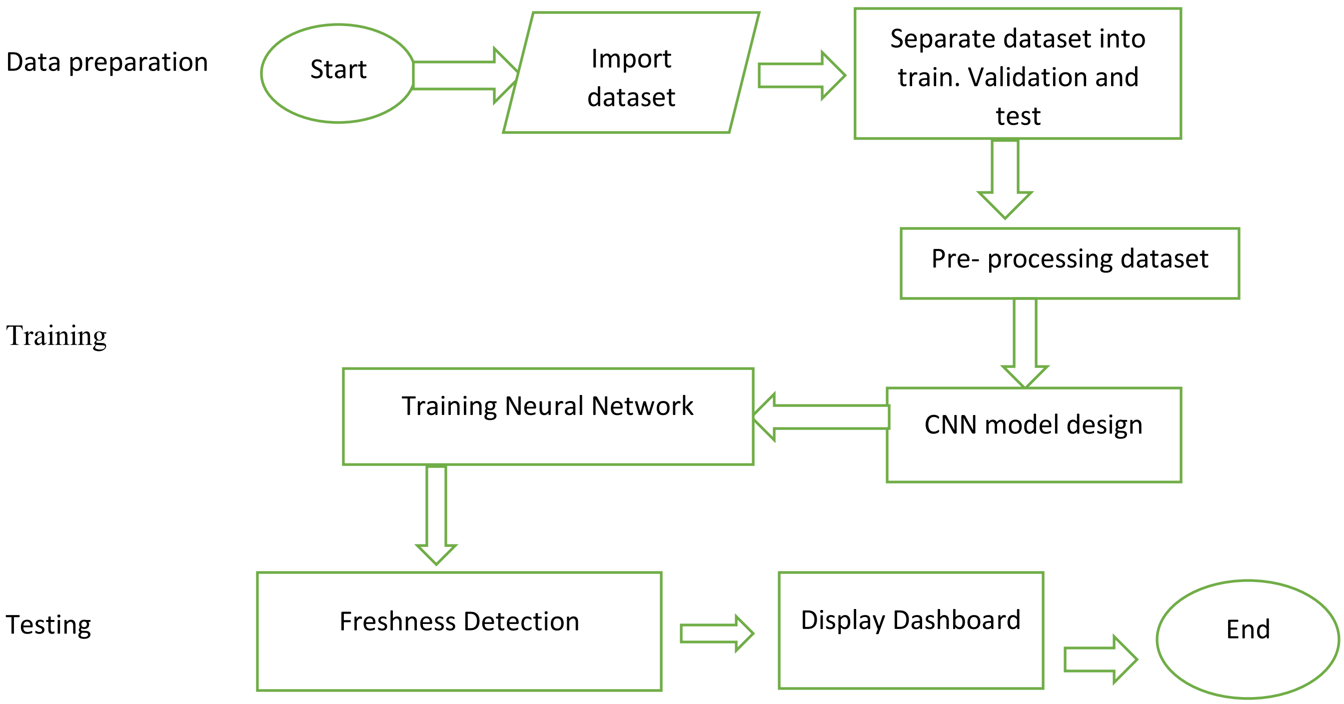
In this project I used Agile software development life cycle, among the benefits are the possibility of modifications, advancement transparency, and a user-focused procedure.

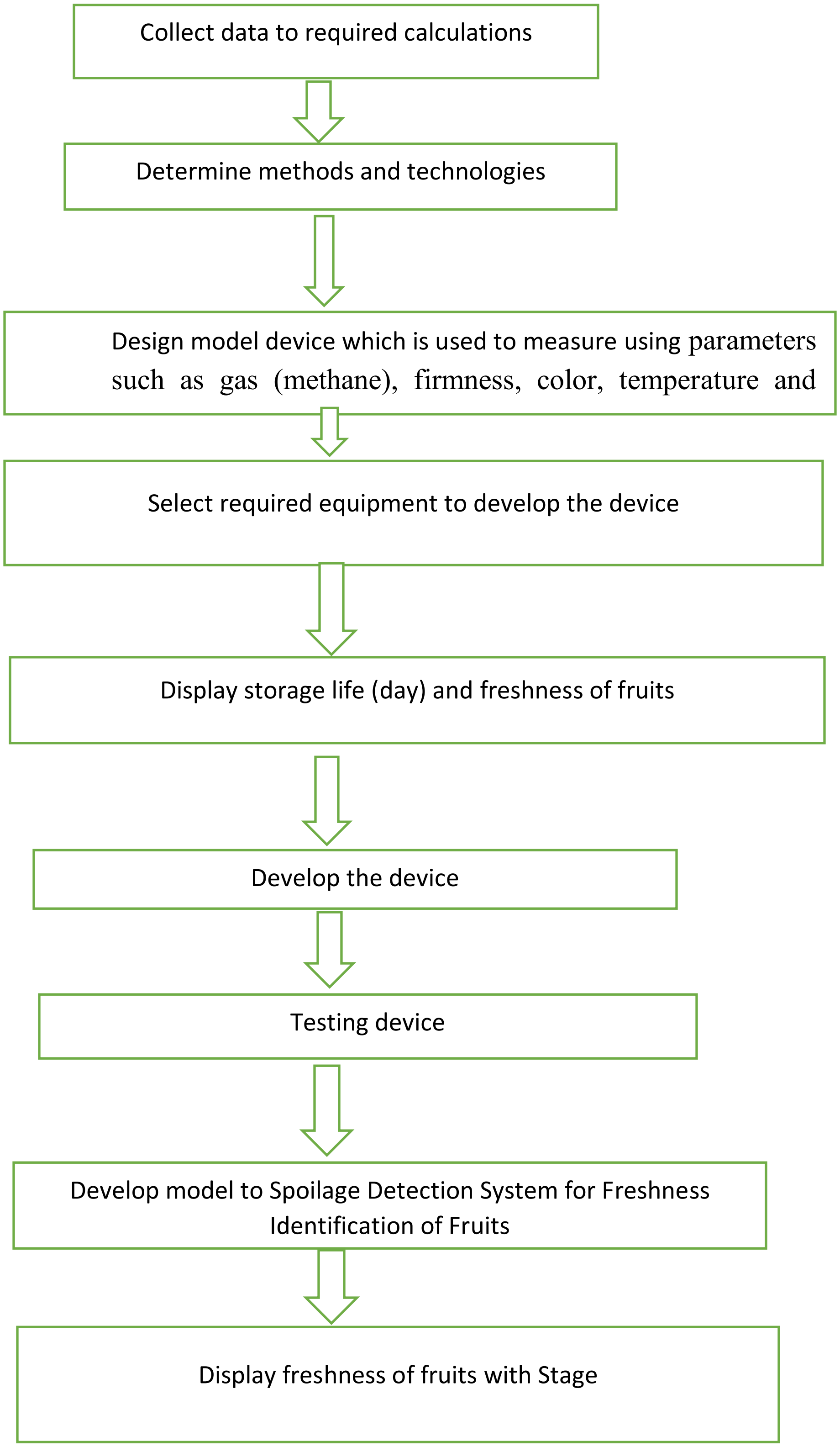
Fresh fruits and vegetables continue "breathing" long after they are harvested, indicating their continued life and potential for growth. Temperature and carbon dioxide (CO_2) are released during this process. The goal of this study is to better comprehend and explore this physiological phenomenon. In particular, the study looks into how fruits produce CO_2 and how much warmth and humidity they have after being harvested fruits were selected for this investigation. There are four main phases of the research, which are as follows:

- Develop a device that can measure using parameters such as gas (methane), firmness, color, temperature and humidity of fruits.
- measure using parameters such as gas (methane), firmness, color, temperature and humidity of fruits after they are harvested and calculate storage life (days)
- Display freshness of fruit as accurately as possible with the results.
- A Software algorithm analyses sensor data to determine freshness evaluating fruits quality through IOT based solution.

3.1 Planning

Diagrams 3.1.1 - flow chart




Collect data to required calculations
Determine methods and technologies
Design model device which is used to measure using parameters such as gas (methane), firmness, color, temperature and
Select required equipment to develop the device
Display storage life (day) and freshness of fruits
Develop the device
Testing device
Develop model to Spoilage Detection System for Freshness Identification of Fruits
Display freshness of fruits with Stage

3.1.1 Identifying Business Values

1. **Waste Reduction**
   Early identification of spoiled fruits and fresh fruits, it helps in reducing food waste in supply chains, such as processing facilities, and retail stores, resulting in cost savings. Fresh vegetables and fruits are wasted the most, typically due to their being purchased in excess or not used in a timeline manner. When stored for maximum freshness, fruits and vegetables will taste better and last longer and assisting in their consumption before they are spoiled.

2. **Shelf Life Extension**
   The monitoring of humidity is considered vital for the preservation of the shelf life of fresh produce. Mainly, it is understood that high humidity is responsible for the improvement of moisture levels that are lost during the process of refrigeration. As a result, it is observed that fruit and vegetables last longer and experience reduced shrinkage. The shelf life of fruits can be extended by assess their freshness, leading to increased sales and reduced losses.

3. **Quality Control**
   The product quality and safety is important thing for through the assurance of fruit freshness helps lead to increased customer satisfaction and loyalty then customers will satisfy.

4. **Management Optimization**
   The system has better management as spoiled fruits are removed from shelves, reducing losses due to overripe or spoiled produce then we can sell only freshness fruits with known about its ripen stage.

5. **Regulatory**
   Compliance with quality and safety standards is crucial for businesses. And a spoilage detection system can assist in ensuring compliance.

6. **Support to Decision Making**
   Valuable data on fruit freshness trends is generated by the system, helps businesses in making informed decisions for storage, and distribution then can get valuable customer satisfaction.

7. **Brand Reputation**
   Consistently providing fresh fruits can enhance a brand's reputation it can supports to build trust with customers then its helps increased customer satisfaction.

8. **Cost Savings**
   Spoilage detection system for Freshness identification automation can result in reduced labor costs associated with manual inspection then we can manage time efficiency.

9. **Market Differentiation**
   Every marketer has competition with others differentiation from competitors can be achieved by higher quality and fresher of products.

3.1.2 Feasibility Analysis

3.1.2.1 Technical Feasibility

Data Availability
Dataset of fresh and spoiled fruits is available, one that is sufficiently large of real-world conditions.
That risk is Collecting and analyzing such a dataset can be time-consuming and expensive, often necessitating collaboration with suppliers, farms, or processing facilities.

Hardware and Software Resources
Verify the availability of the hardware and software as machine learning frameworks required for model development.
That risk is High-performance hardware, for deep learning, can be expensive. The availability of skilled to manage and maintain these resources is also essential.

Skills
Assess whether the necessary expertise in machine learning, and data preprocessing is possessed by this project.
Risk is Building a state-of-the-art freshness detection model necessitates a team with advanced skills in these.

Integration with Sensors
Determine the feasibility of integrating sensors such as temperature, humidity, gas sensors with the system for real-time monitoring.
Risk is Integrating sensors may require additional hardware, firmware development, in sensor technology.

Real-time Processing:
Determine whether the system can provide real-time freshness assessment.
Risk is achieving real-time processing may require the optimization of algorithms and hardware for performance with sensor technology.

Scalability
System can be scaled to handle a large volume of fruits in a production environment.
Risk is Scaling the system may involve additional infrastructure and computational resources whether you are in communication with a client or planning project's budgets, firstly we need to have an overview of how the various stages work.

3.1.2.2 Financial Feasibility

Benefit for Cost Analysis: -
Cost benefits analysis helpful for reduce waste, improved quality. The costs associated with developing the system, including hardware, software, data collection and preprocessing, model development, and personnel expenses its associated with obtaining necessary permits.

Operational Costs

Costs to modify existing business processes project ongoing operational expenses, such as maintenance, data annotation, hardware maintenance, and personnel salaries.

Pricing Strategy:

Determine the pricing strategy for your system, considering the market demand, competition, and the value your system provides to customers. Crucial to ensure that it is both affordable to the target audience and profitable for the business

Market Analysis

Market Size Assess the size of the target market of freshness detection system. Consider the number of potential customers and their willingness to pay for such a solution.
Market Trends: Analyze market trends, such as the increasing demand for food quality and safety, and how your system with these trends.

Cash Flow:

Cash flow included Revenue Projections, Cost Projections, Initial Investment that outline the look for inflows and outflows of funds over the project's timeline. This helps in managing cash flow and ensuring financial stability.

Break-Even Analysis:

helps determine how long it will take project to become profitable to calculate the point at which the project starts generating a profit that can provide insights into when you can expect to see a return on investment.

Exit Strategy:

Exit strategy helps for ensure long-term financial sustainability, such as selling the technology or the entire project to a larger company, in case the project does not meet financial expectations.

Compliance Costs:

These can impact the financial feasibility and its include food safety, various regulations such as safety standards and certifications to gain trust from the market.

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3.1.2.3 Operational Feasibility

Satisfy with Current Systems:

Determine whether the organization's current IT infrastructure can be easily connected with the freshness detecting system. To guarantee a seamless transition, reduce interruptions, scale the system as demand increases, and adjust to changes, compatibility is crucial.

Technical specifications:

It is crucial to assess the system's technical needs, which include those related to hardware, software, and network infrastructure. Make sure that the organization's resources and capabilities meet these needs.

The ability to scale

Check to see if the system can grow to meet future increases in the number of fruits that need to be tracked; it should be able to do so without experiencing a noticeable drop in performance. The advantages of this technique to promote support from all parties involved.

User Education and Acceptance

The success of this initiative depends on the users, employees, and other relevant parties such as operators, technicians, and support staff getting the necessary training. Ascertain whether the company can offer the required training, whether users are eager to embrace the new technology with its user-friendly interfaces, and whether it can offer thorough training to make adoption simple.

Upkeep and Assistance:

In order to manage the capacity to offer continuous assistance, we must take care of the system's maintenance requirements, which include regular updates, hardware maintenance, and troubleshooting.

Availability of Resources

Examine whether the real world has the funding, manpower, resources, and equipment required to successfully install and maintain the system.

Duration and Due Dates

It is crucial for the project to be finished on schedule in order to win over the loyalty and satisfaction of the client. Implementation delays may have an impact on operations, thus it's important to set up channels for users to offer suggestions and comments.

Initial Testing

able to carry out trial runs or pilot tests to evaluate the system's performance in an actual operating environment. This can assist in recognizing and resolving operational issues prior to full deployment as to verify user engagement, data accuracy, and system functionality, conduct small-scale trials.

3.1.2.4 Legal Feasibility

Compliance:

Determine the relevant regulations and standards that apply to freshness detection system, particularly in the food industry and fruits market. Ensure the freshness detection system complies with food safety, quality.

Data Privacy and Security:
If the system collects and stores data, assess data privacy laws and regulations in tool, and those of related market customers. Implement measures to protect the privacy and collect of data, especially if personal information is involved.

Intellectual Property Rights:
Using third-party software or components. And important to verify that what we have the necessary licenses and permissions.

Product Liability:
When issues that may arise if the system fails to detect spoiled fruit or provides inaccurate information. Implement clear disclaimers and terms of use to manage legal risks.

Contractual Agreements:
When tool is collaborating with suppliers, customers, or partners, review and negotiate contractual agreements that define responsibilities and legal liabilities related to the system.

Data Ownership:
Clarify the ownership of data generated by the system to your organization, your customers, or other stakeholders, and establish data usage and sharing agreements accordingly.

Export Control:
When system involves technology or components that are subject to export control regulations, ensure compliance with export laws and obtain any required licenses or permits.

Consumer Protection
When used by consumers, ensure that it adheres to consumer protection laws, including laws related to product labeling, advertising, and transparency.

Food Traceability:

When Used in the supply chain, consider food traceability requirements and ensure that your technology can provide accurate tracking and reporting of the origins and movement of fruits.

3.1.2.5 Schedule Feasibility

Project Timeline:
Project time line is important thing for define a detailed project timeline that includes all phases, tasks, and milestones, from data collection to system deployment, that it aligns with the organization's goals and deadlines.

Resource Availability:

Before deployment, it is crucial perform complete testing and quality assurance to ensure. Then it can know that sensor data is accurate and trustworthy. Verifying the system's ability to instantly assess the freshness of the input is essential during real-time processing to avoid mistakes and poor decision-making. this section represent ethical issues need to manage and minimize and evaluate the availability of resources, including budget, to determine if they can support the project.

Risk Assessment:
Identify and develop risk contingency plans for Risks with respect to the project team or Risk with respect to the customer / user.

Project Management
Implement effective project management plan practices will support to Monitoring and planning. Its including regular progress monitoring, communication, and adjustments to the schedule as needed for current project and end of final project.

Quality Assurance:
Allocate time for quality assurance and testing to issues before deployment. Testing can lead to delays and compromised system performance and compatibility such as analysis collected data.

Change Management:
Changes in project scope or requirements and assess how they may impact the project schedule and have a process in place for managing benefits can improve fruits quality and safety, lengthen shelf life, decrease waste, and increase customer happiness.

Contingency Planning:
Develop contingency plans is an included planning, monitoring, organizing and managing all the project resources and alternative schedules in project or delays occur. When failures or data availability issues included creation of project planning tools like work breakdown structures (WBS), budget estimates for resources as part of quality control programs, the standards contain national and international regulations aimed at strengthening good hygienic and agricultural practices (GHPs) throughout the entire supply chain.

Communication Planning:
Communication plan helps a clear and effective communication plan to keep all project then it helpful stakeholders informed about progress, issues, and changes in the schedule.

Documentation:
Maintain detailed project documentation to track progress and to have a record of all decisions its included first-person accounts of events and experiences and changes made during the project that can be divided into major categories in farm public records, and personal documents about included information in farm.

3.1.3 Work Plan

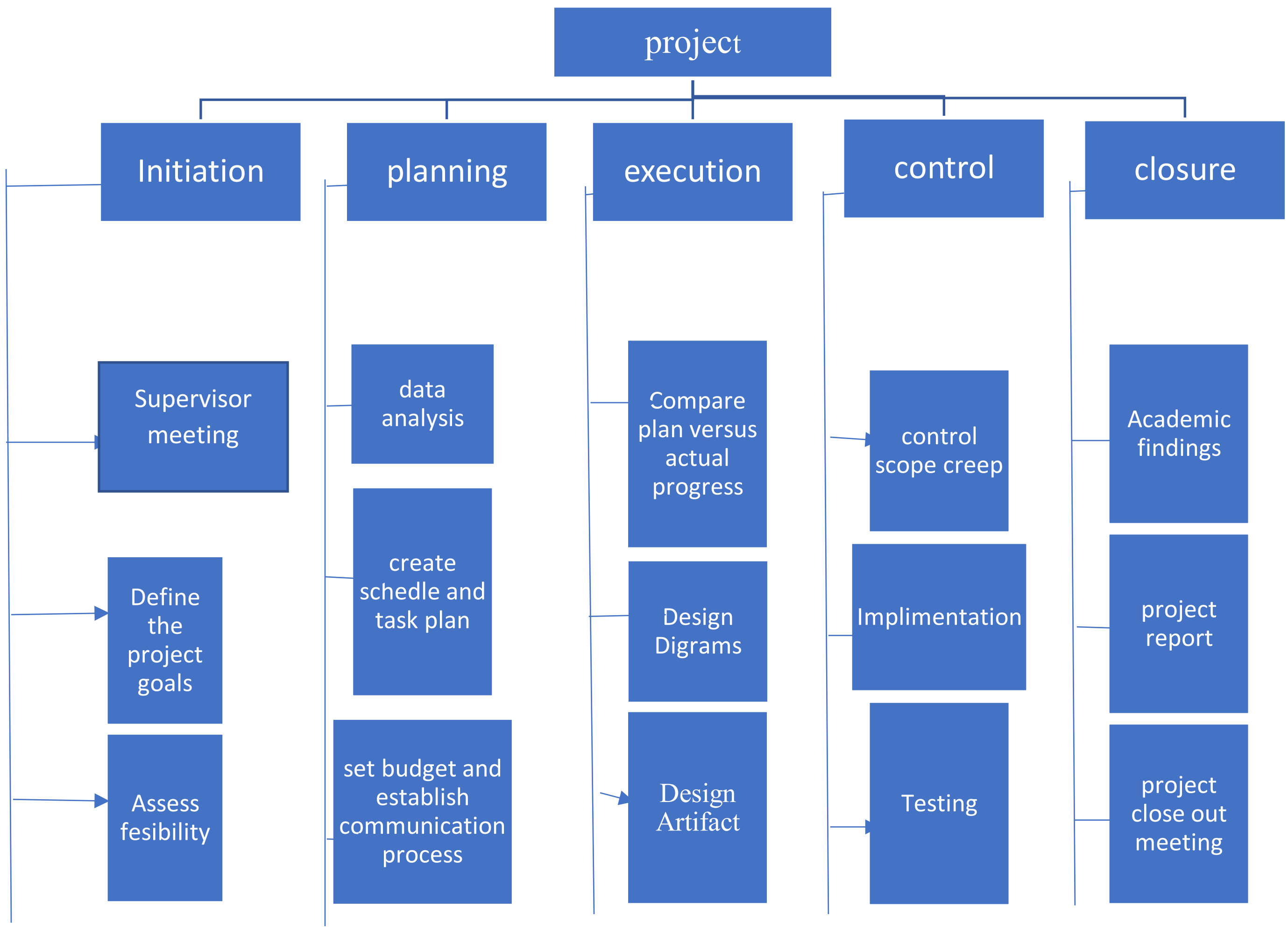


Figure 1:3.1.3.1: Work Break Down Structure

3.2 Analysis and Requirement Gathering

In order to develop and implement food spoilage detection techniques, which can improve food quality and safety, extend shelf life, decrease waste, and increase customer satisfaction, data collection, documentation, and analysis of the requirements and expectations of define achieve must be done methodically. In this study, qualitative data collection techniques proved to be quite beneficial. Information gathered by looking at already existing records, observing how farm management transactions are conducted, and speaking with farm employees The farm manager, the employee manager, the accounts manager, and staff were among the officials who were interviewed. Additionally, I used farmers and farming areas in several Providences that were randomly picked for my sample.
In this investigation, temperature, humidity, and CO2 levels were measured. The proposed model was applied to a few fruit varieties, papaya, banana, and mango.

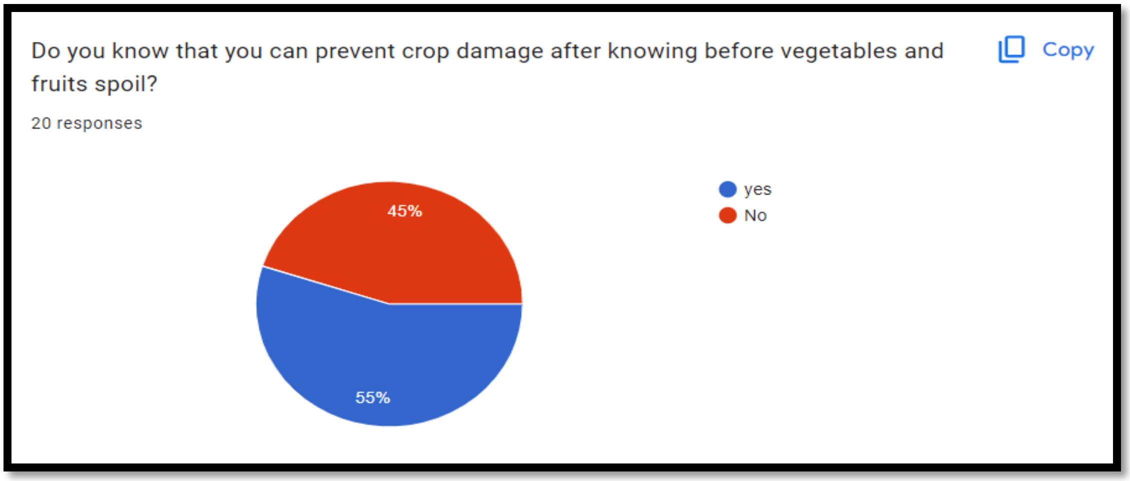
The Firmness, temperature, humidity, and release of the methane gas sensor MQ-4 and the temperature and relative humidity sensor DHT11 were all clearly displayed in the data that was gathered. Initially, I used sample data to obtain these values by collecting fruits such as, papayas, bananas.
This steps can be represents determine the beginning and ending methane values ,Variations in temperature, Firmness, humidity, and CO2 Obtain these values for days 1, 3, and 7.

3.2.1 Analysis

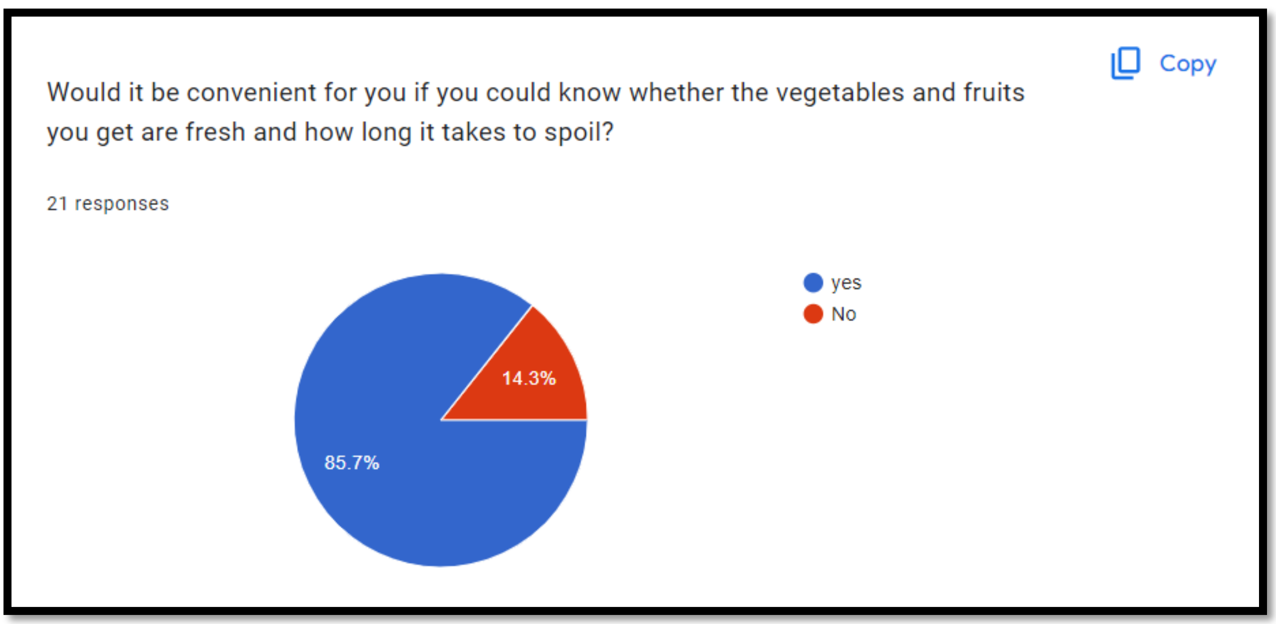
The purpose of this interview was to learn more about the fruit farm official's methods for processing reservations and the many ways they counsel consumers about the booking and reservation process. Using interviews as a method of data collection allowed me to obtain information from the respondents and a chance to learn more about the ones that are now in use. conducted interviews with a few farm employees. I may obtain information for my present technique and comments from this interview. The interview guide utilized is available in this report's appendix.

3.2.2 Requirement Gathering

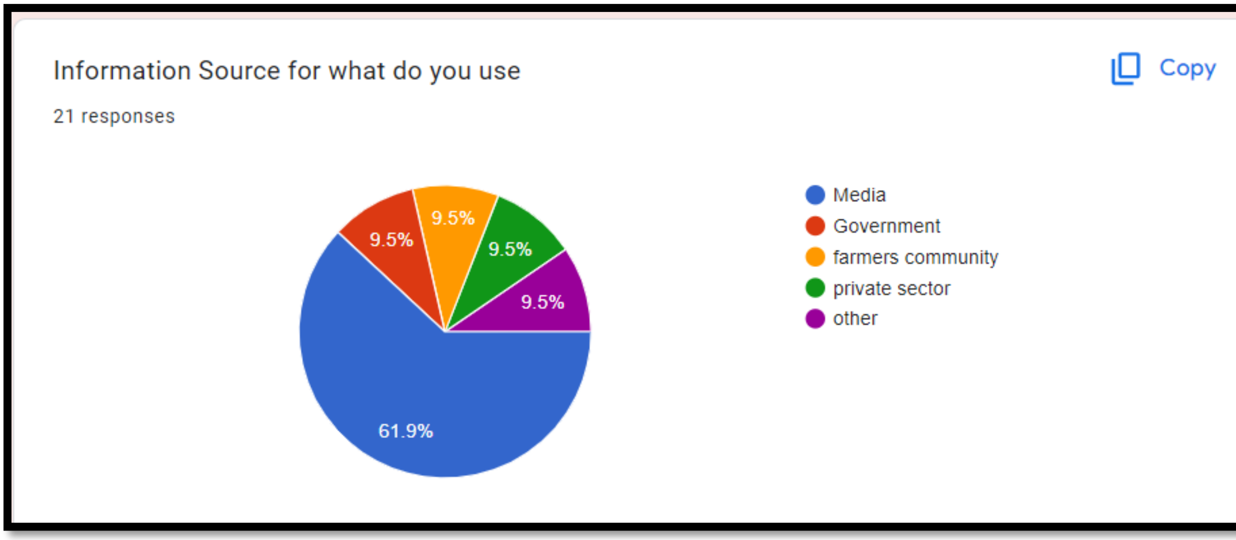
Analysis of questionnaire https://forms.gle/wVmbmEM1bufrSYu48



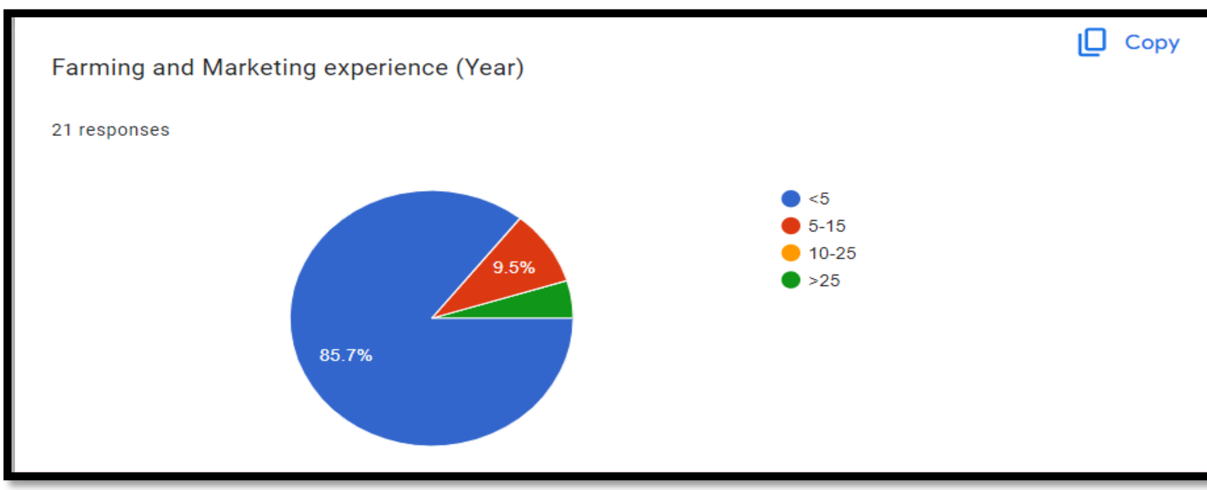
The above pie chart shows percentages of person who grows vegetables and fruits for home. The highest percentage of people are known can prevent crop damage after knowing before vegetables and fruits spoil. while the least percentage of people are not knowing can prevent crop damage after knowing before vegetables and fruits spoil.



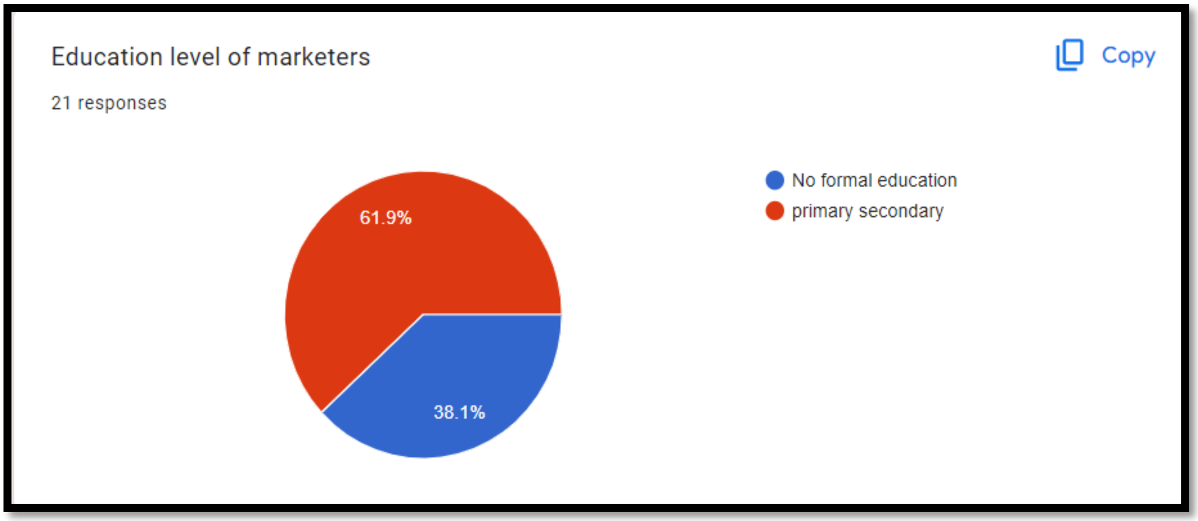
Though most of them like know whether the vegetables and fruits are fresh and how long it takes to spoil. some are don't know that. Considering above details, we can clearly mention that the most of peoples are knowing can prevent crop damage after knowing before vegetables and fruits spoil.



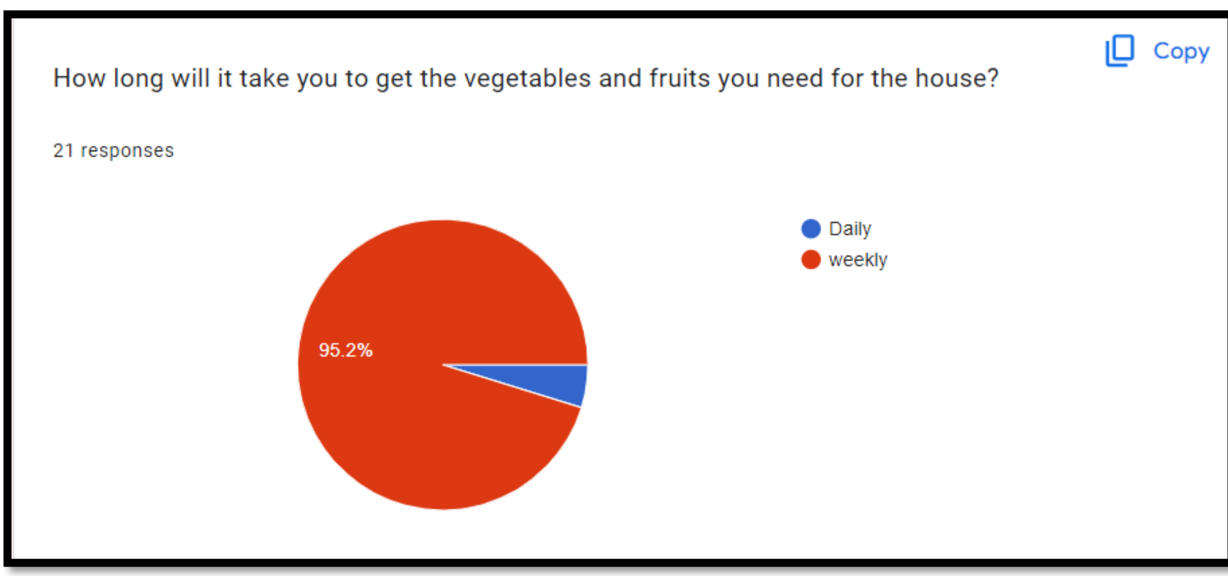
In this case, marketer need to know about the market conditions and price. Therefore, the Shows through the questionnaire survey 61.9% of respondents get information via the media related site. Besides, 9.5% of respondents said they would get information from the farming community and private sector / NGOs, while 9.5% reported receiving information from another source. Considering above details, we can clearly mention that marketing information system helps to know all information for their activity in these sectors



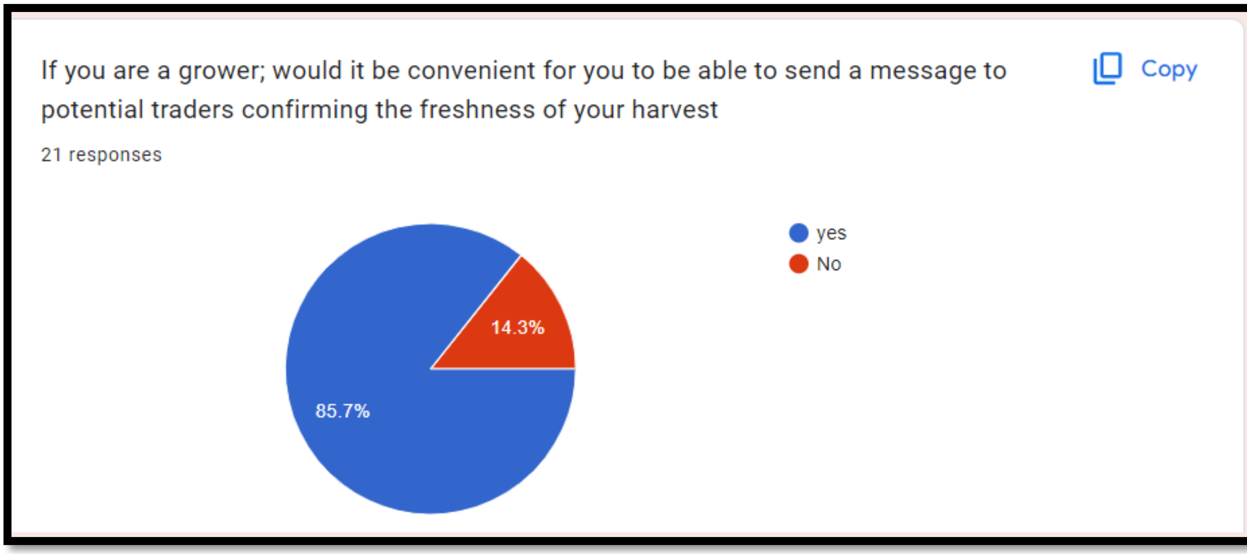
According to the pie chart, the highest percentage of people has more than five-year experience for farming and marketing experience it is 85.7%. While the least percentage of farming and marketing experience has less than twenty-five years it is 4.8%. The majority of people have more than five years of experience in farming and marketing, constituting 85.7% of the group, it is good for represent our new service because of The majority of people have experience for farming and marketing.



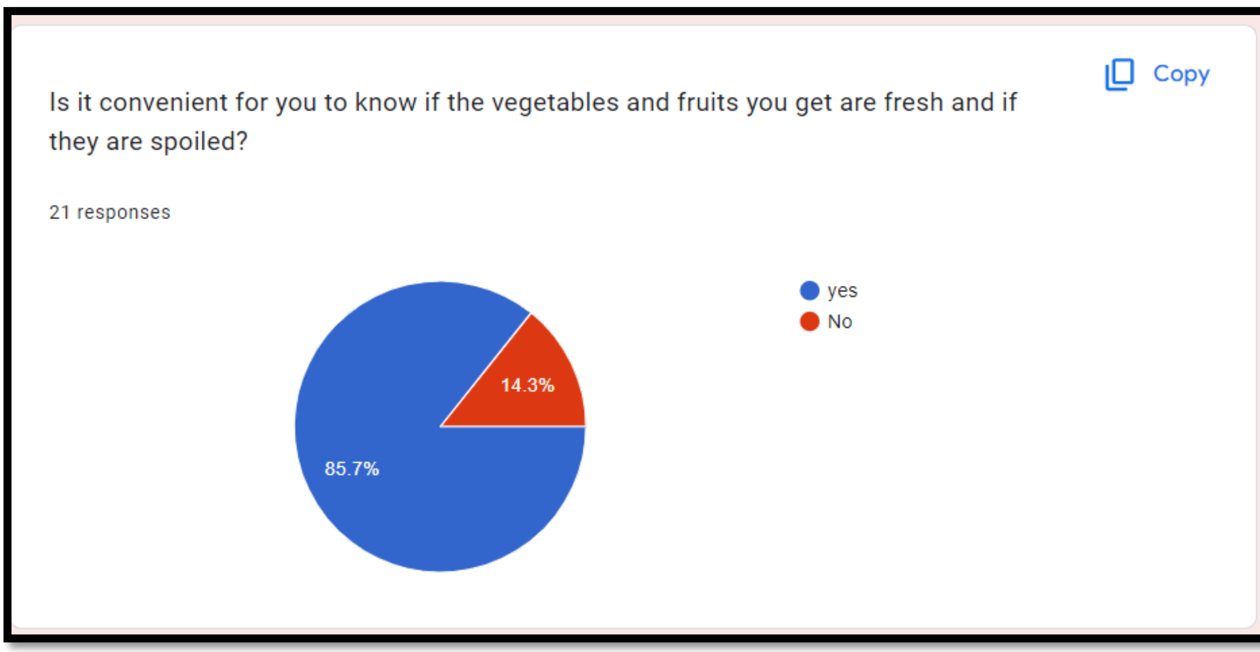
The majority of people in the sample have primary and secondary education level of marketers it is 61.9%., while only a small minority, 38.1% no formal education of marketers it is 38.1%.

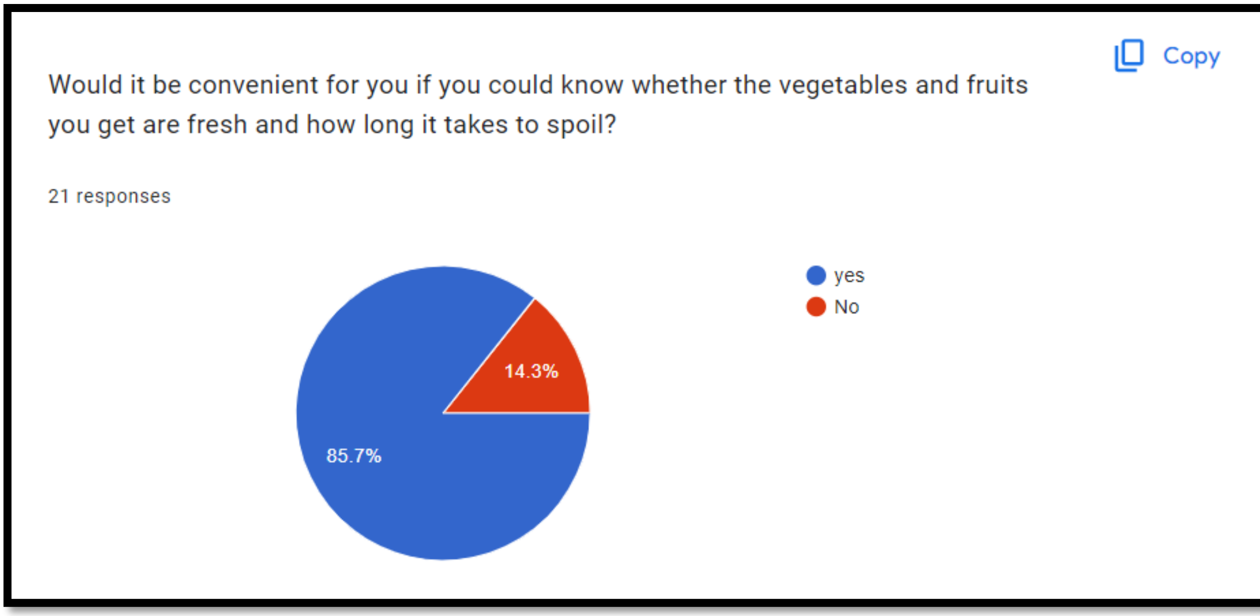


The majority of people get vegetables and fruits for weekly, it is 95.2%., while only a small minority, of people get the vegetables and fruits for daily. Considering above details, we can clearly mention that the most of people get vegetables and fruits for weekly therefore would it be convenient for to be known fruits and vegetables are fresh or they are spoil.

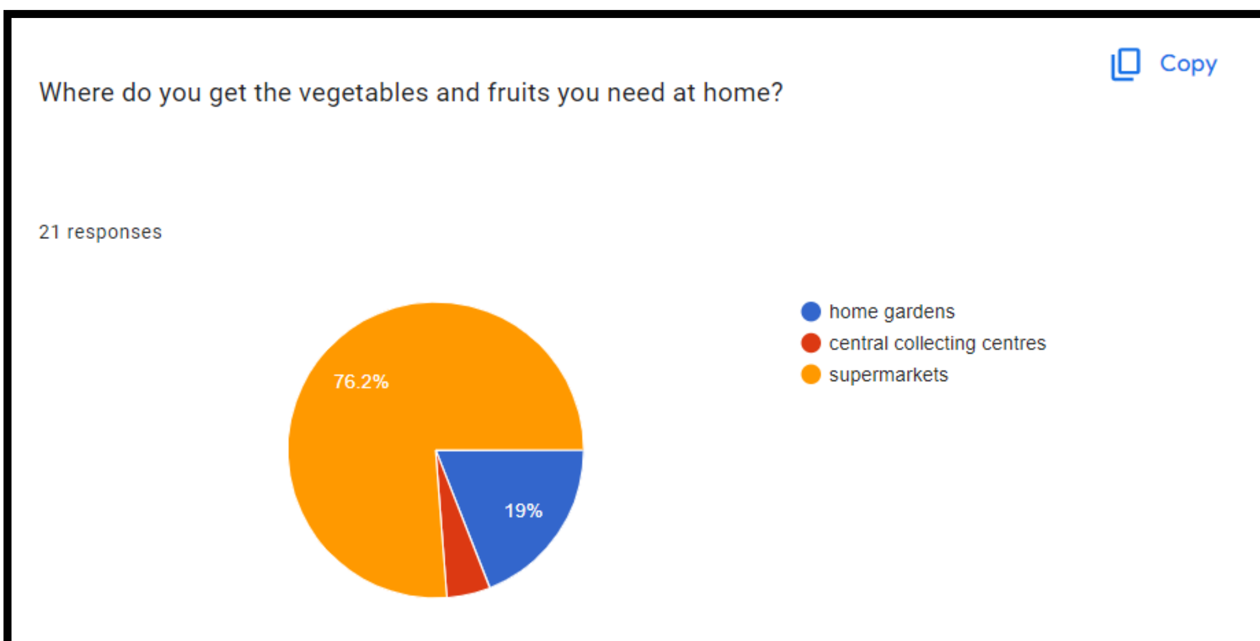


This question gives a knowledge about the important detection system for freshness identification. Most of them know it will be important. Therefore, the Shows through the questionnaire survey 85.7% of respondents get information yes diction, we can clearly mention that marketing information system helps to know all information for their activity in these sectors





This question gives a knowledge about the important detection system for freshness identification. Most of them know it will be important. Therefore, the Shows through the questionnaire survey 85.7% of respondents get information via the media related site, we can clearly mention that marketing information system helps to know all information for their activity in these sectors.



According to the pie chart, the highest percentage of people get vegetables and fruits from supermarkets it is 76.2 %. While the least percentage of people get vegetables and fruits from central collecting centers. 19% percentages of people get vegetables and fruits from home gardens.

The questionnaire was Fruit Farm on implementing project. The aims of the questionnaire were to farm were sharing information in a manner that could lend itself to a spoilage detection system for identification freshness solution, find out if any farm are interested in or are already using detection system their services.

Table 1: Response of fruit farm employees in Fruit farm on whether they think their companies should implement fruit freshness and Spoil detection.

Table 1:3.2.2 : Questionnaire

for 6 fruit farm staff members and 6 employees:

	May need detection system	Don’t need detection system	No idea	total
staff	3	2	1	6
Employee	4	1	1	6

3.3 Designing

3.3.1 Physical Design

In physical designing, there is a physical design in system and there is a physical design in a detection of freshness of frits using making learning techniques. In system physical designing I have used use activity diagrams

Figure 3.3.1.1 represents the activity diagram of the proposed system.

Figure 3.3.1.2 represents the DFD diagram of the proposed system.

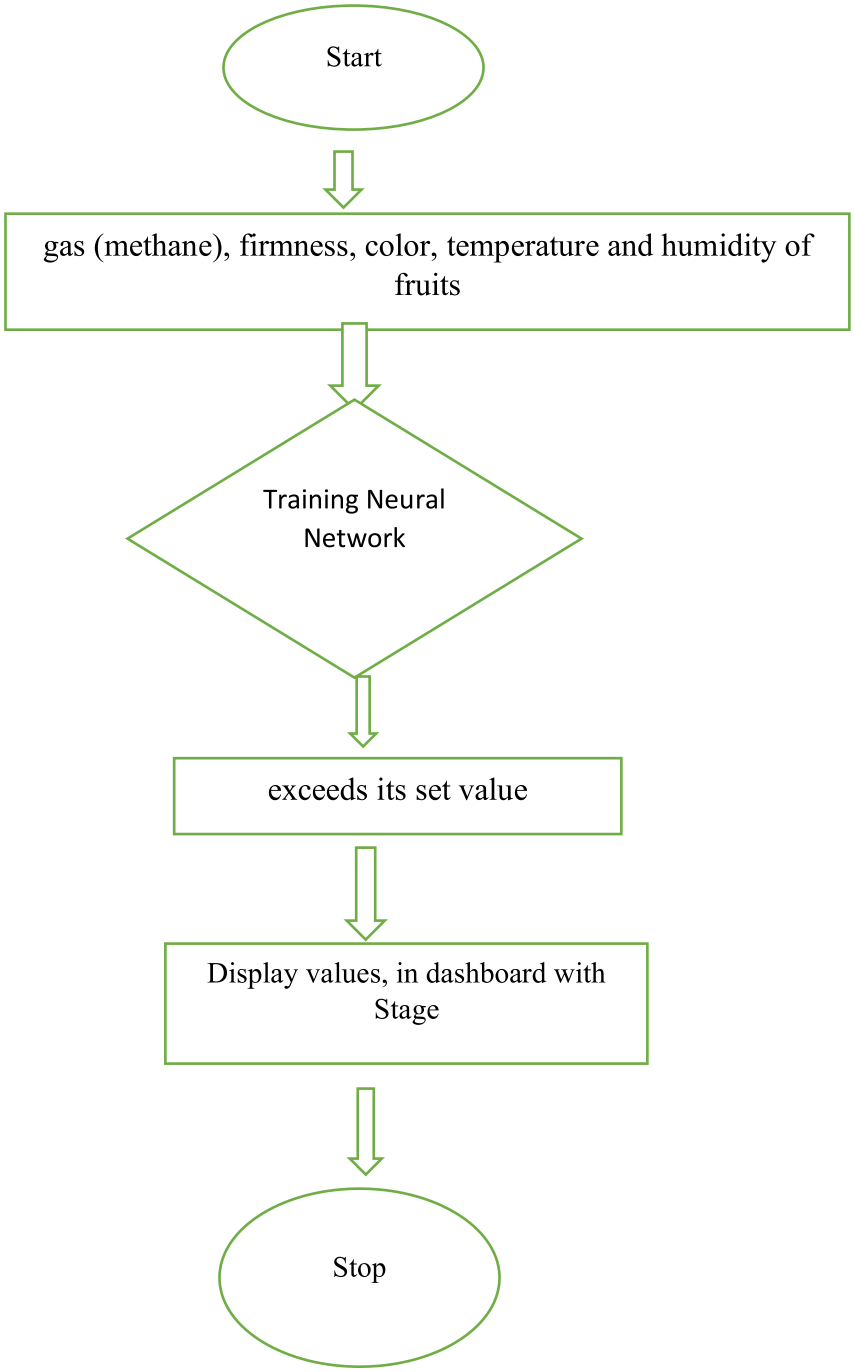
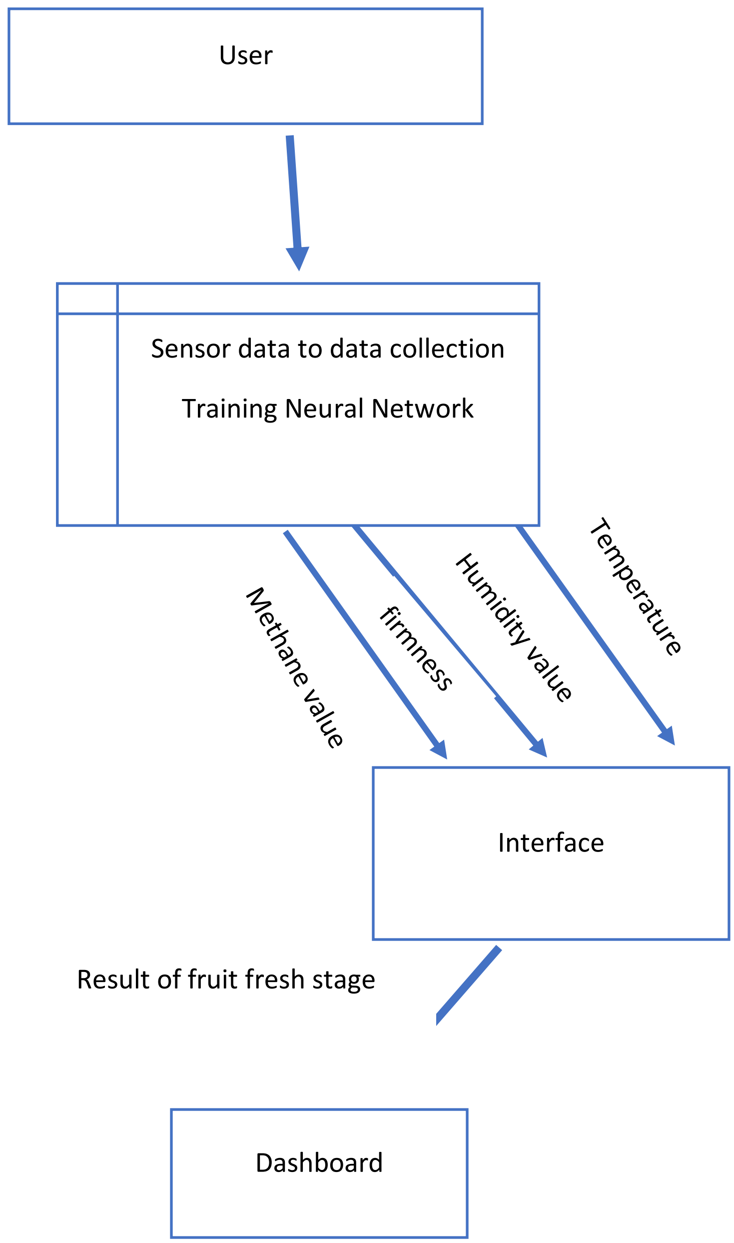


Figure 2:3.3.1.1 : activity diagram

Figure 3:3.3.1.2 : DFD diagram



3.3.2 Architecture Design

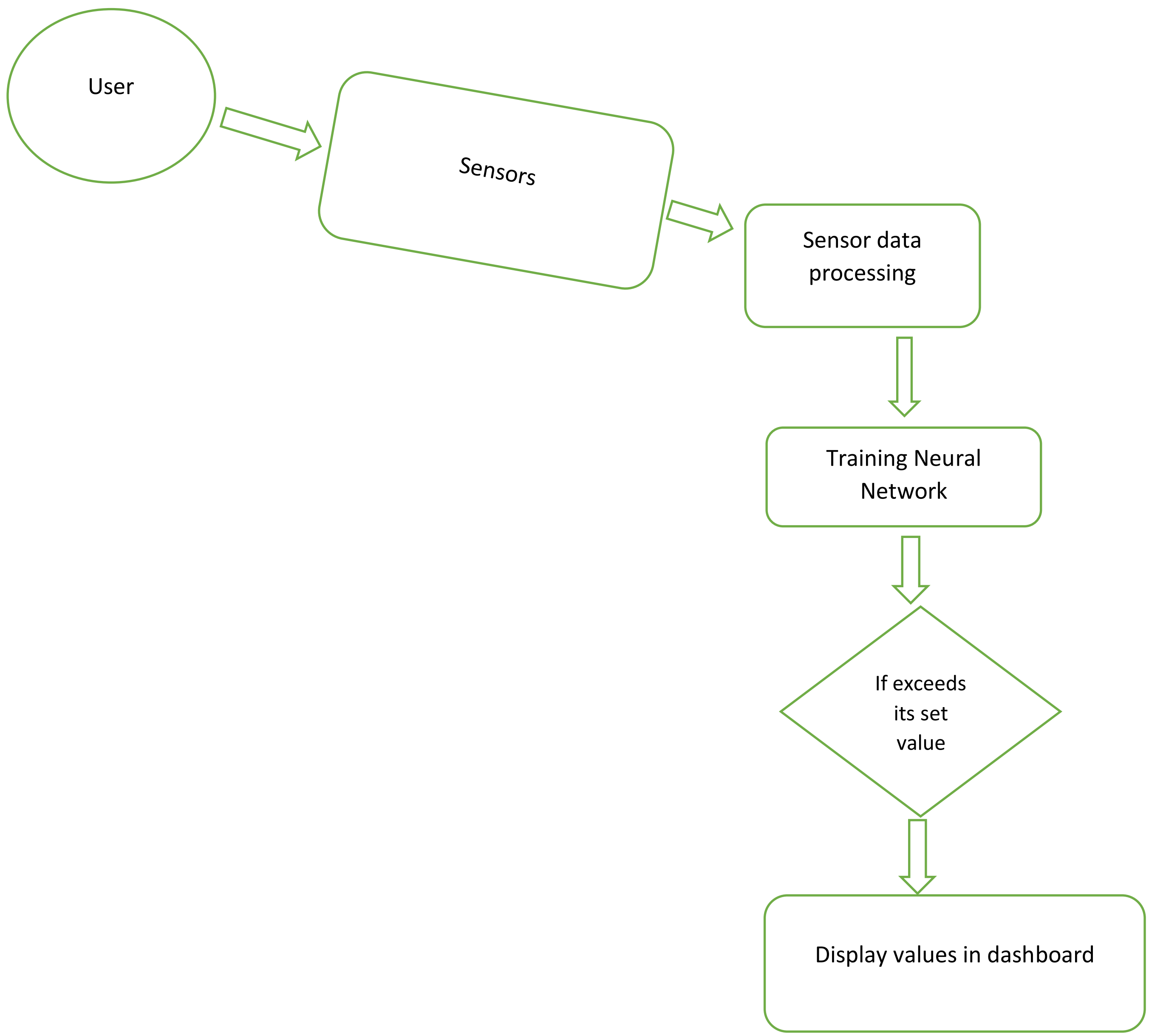


Figure 4:3.3.1.3 : DFD diagram

3.3.3 Interface Design

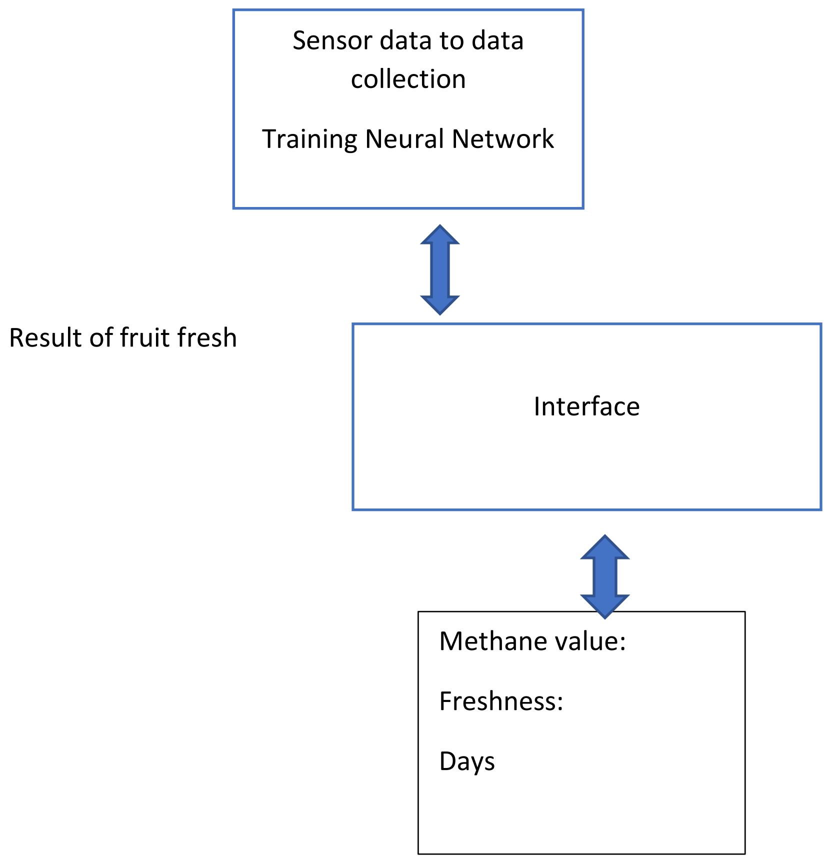


Figure 5:3.3.3.1: Interface Design

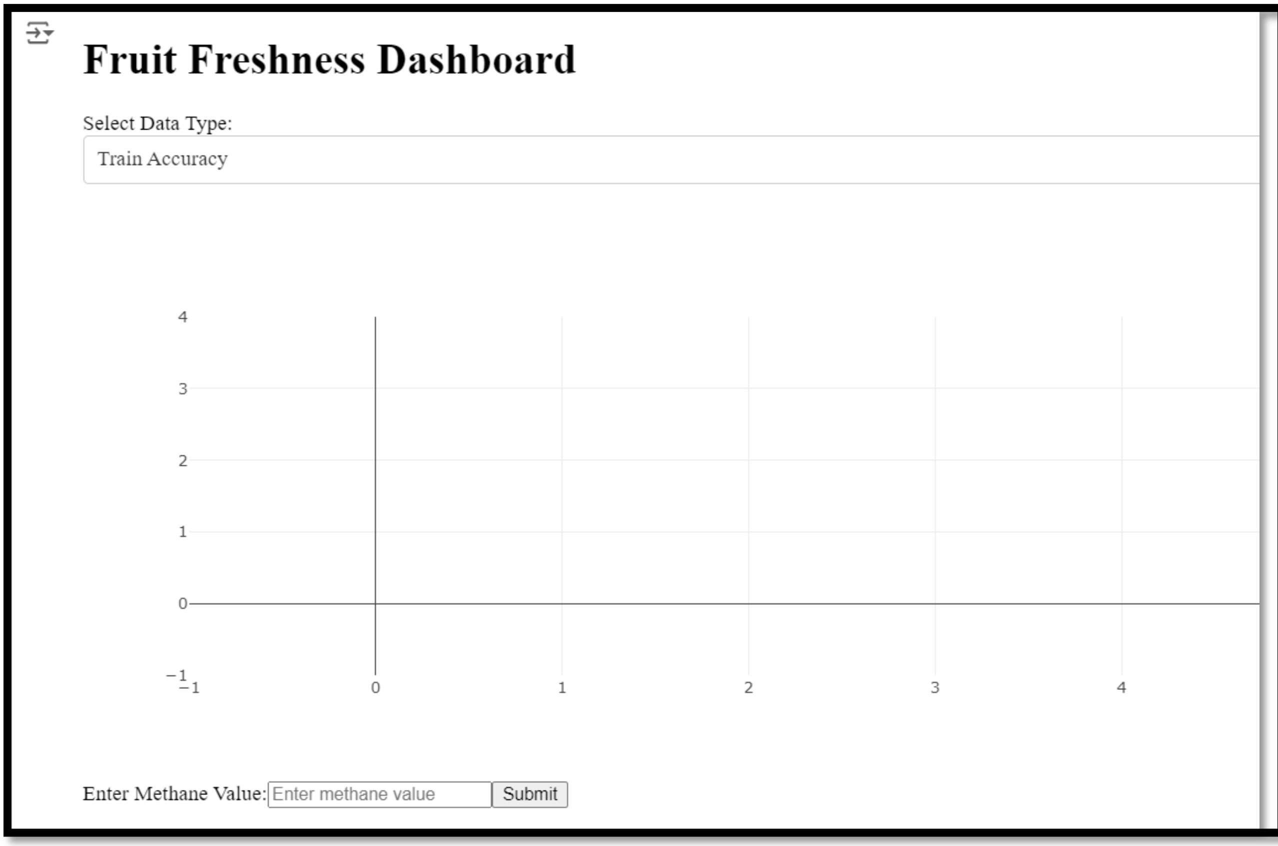


Figure 3.3Fruit Freshness Dashboard

3.4 Implementation

Components:

- Arduino UNO Board
- Jump wire
- Breadboard
- Methane gas sensor MQ-4
- DHT11 Temperature and Relative Humidity sensor.
- FSR sensor
- LED

Step 1: **Collected sensors data**

- First, need collected sensors data of detecting methane, firmness, temperature, and humidity levels. The sensors should be connected to a microcontroller like Arduino.
- **Methane Sensor**: Use a sensor like MQ-4 for detecting methane.
- **Temperature Sensor**: DHT11 sensor can be used for temperature and humidity sensing.
- **Firmness Sensor**: pressure sensor to measure fruit firmness

Step 2: **Data Collection**:

- Measure the gas, temperature, humidity, and firmness data on four days (day of harvest, 3 days, 1, day 5, day6, day7) and Record the sensor readings every 45 minutes for each fruit group.

Step: 3 **Build a Machine Learning Model**

- Make a dataset with input features like fruit type, difference in methane, temperature, humidity, and texture and get target variable freshness stage.

Step 4 : **Train a CNN:**

- Design a simple CNN model with fully connected layers. After that evaluate the model using metrics to assess prediction accuracy with learning rate, number of layers with number of epochs for better performance.

Step 5: **Display values on dashboard:**

When enter the values represents fruit stage.

3.5 Testing

3.5.1 Unit Testing

1. get the methane value, humidity value and temperate values. The values of the harvested fruits are obtained at the time when the fresh fruits are harvested, when there is a slight green mixture.

Figure:3.5.1.2: slight green mixture.

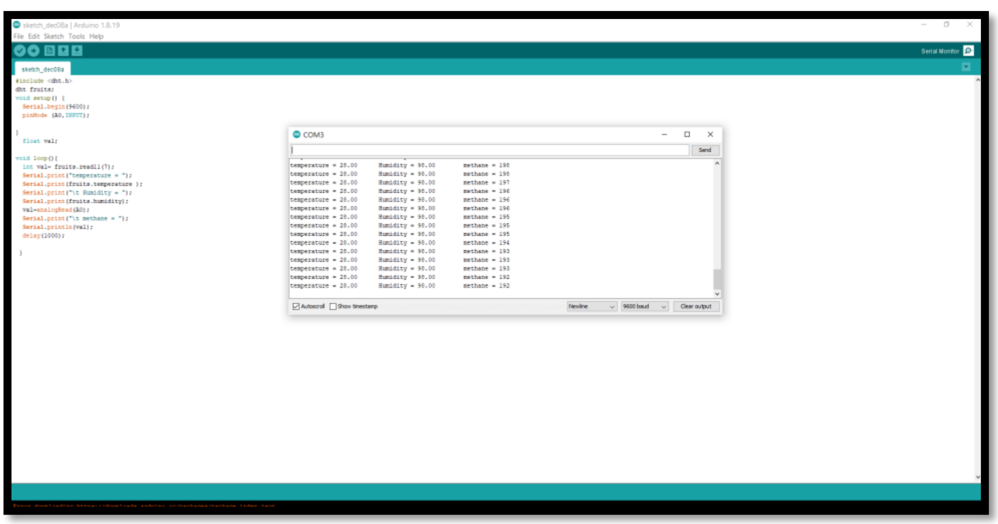


Figure 67:3.5.1.3 : output

If it is equal to the given values, the green LED bulb lights up it shows that the fruit is fresh.

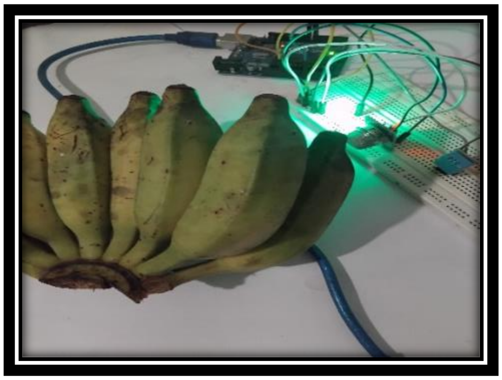


Figure 7:.5.1.4: green LED bulb lights up

3.5.2 Integration Testing

Build a Machine Learning Model

Here I proposed a design of computer vision-based technique using deep learning with the Convolutional Neural Network (CNN) model to detect fruit freshness Stage. Fruit has a period where the fruit is said to be fresh fruit during this time many fruit supply companies publish the fruit as unfit for consumption and lack the accuracy of the fruit sorting process as unsuitable packaging. In this research I selected two for papaya and banana local name (Ambul) /common name (Sour Banana). We need to categorize the fruits into two groups as green and yellow, and test them on four selected days, the day of harvest, three days after harvest, one week after, to observe the changes in these four factors (methane, temperature, humidity, and texture). After entering the type of fruit in methane, temperature, humidity, and texture after 45 minutes as inputs for the model, the model will predict the freshness of the fruit as a Stage This dataset includes 230 values of fruit and rotten fruit. After they collect data, they preprocess data by cropping, resizing the data as needed then I can be designing a model that is planned to be used and a list of specified parameters such as the level of learning and the number of training epochs. For the testing process data trained with the CNN model.

```python
# Importing necessary libraries
import numpy as np
import pandas as pd
import tensorflow as tf
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv1D, Flatten, Dropout
```

```python
# Load the dataset (assumed to be in CSV format)
data = pd.read_csv('/content/fruit_freshness.csv')
```

```python
# Display first few rows of the dataset
data.head()
```

	Min	Type	Temperature	Humidity	Methane	Firmness	color	fresh fruits (Day)	Stage
0	1.0	Banana	29	93	227	364	green	fresh fruits (Day2)	ripening process initate
1	2.0	Banana	29	93	230	364	green	fresh fruits (Day2)	ripening process initate
2	3.0	Banana	29	93	238	364	green	fresh fruits (Day2)	ripening process initate
3	4.0	Banana	29	93	240	303	green	fresh fruits (Day2)	ripening process initate
4	5.0	Banana	29	94	243	303	green	fresh fruits (Day2)	ripening process initate

Figure 3.5.2.1. Description of dataset

I developed the model for this project using TensorFlow, an end-to-end open-source platform for machine learning. Within TensorFlow, Keras serves as a high-level API that offers a productive interface for handling machine learning challenges. In this study, Keras was used to define the model and preprocessing layers, mapping columns from the CSV file. This format was employed to train the model

```python
# Select features and the target variable (assuming 'Stage' is the target)
X = data[['Min', 'Temperature', 'Humidity', 'Methane', 'Firmness', 'color ', 'fresh fruits (Day)']]
y = data['Stage']  # 'Stage' is the freshness stage you want to predict

# Perform one-hot encoding for categorical variables if needed
X = pd.get_dummies(X)

# Normalize the features
scaler = StandardScaler()
X = scaler.fit_transform(X)

# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Reshape the input to be suitable for Conv1D
X_train = np.expand_dims(X_train, axis=2)
X_test = np.expand_dims(X_test, axis=2)

from tensorflow.keras.layers import Input, Conv1D, Flatten, Dense, Dropout
from tensorflow.keras.models import Sequential

# Define the CNN model
model = Sequential()
```

Figure 3.5.2.2. Define CNN Model

```python
# Define the CNN model
model = Sequential()

[14] # Add a Conv1D layer with 64 filters, kernel size of 2, and ReLU activation
     model.add(Conv1D(filters=64, kernel_size=2, activation='relu', input_shape=(X_train.shape[1], 1)))

[15] # Flatten the output from Conv1D to feed into Dense layers
     model.add(Flatten())

[16] # Add Dense layers for classification
     model.add(Dense(128, activation='relu'))
     model.add(Dropout(0.5))  # Dropout to prevent overfitting
     model.add(Dense(64, activation='relu'))

[17] # Final output layer with softmax activation (if multiple classes for Stage)
     model.add(Dense(len(np.unique(y)), activation='softmax'))

[18] # Compile the model
     model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])

[19] # Model summary
     model.summary()
```

Figure 3.5.3. Compile the Model

```
# Check dtypes if X is still a DataFrame
print(data.dtypes)
```

```
Min                   float64
Type                   object
Temperature             int64
Humidity                int64
Methane                 int64
Firmness                int64
color                  object
fresh fruits (Day)     object
Stage                  object
dtype: object
```

Figure 3.5.3.4Data Type

```
# Replace NaN values with the mean of the column (for example)
X_train = np.nan_to_num(X_train)
X_test = np.nan_to_num(X_test)
```

```
# Perform one-hot encoding on categorical columns
X = pd.get_dummies(data[['Min', 'Temperature', 'Humidity', 'Methane', 'Firmness', 'color ', 'fresh fruits (Day)']])
```

```
# Ensure X is a DataFrame at this stage
print(X.dtypes)
```

```
Min                                       float64
Temperature                                 int64
Humidity                                    int64
Methane                                     int64
Firmness                                    int64
color _green                                 bool
color _yellow                                bool
fresh fruits (Day)_ (Day7)                   bool
fresh fruits (Day)_fresh fruits (Day2)       bool
fresh fruits (Day)_fresh fruits (Day4)       bool
fresh fruits (Day)_fresh fruits (Day5)       bool
fresh fruits (Day)_fresh fruits (Day6)       bool
dtype: object
```

Figure 3.5.3.5 Data Frame at this stage

3.5.3. System Testing

```
# Train the model
history = model.fit(X_train, y_train, epochs=50, validation_data=(X_test, y_test), batch_size=32)

Epoch 22/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step - accuracy: 1.0000 - loss: 0.0318 - val_accuracy: 0.9783 - val_loss: 0.0466
Epoch 23/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 19ms/step - accuracy: 0.9882 - loss: 0.0349 - val_accuracy: 0.9783 - val_loss: 0.0317
Epoch 24/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step - accuracy: 0.9891 - loss: 0.0253 - val_accuracy: 1.0000 - val_loss: 0.0229
Epoch 25/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step - accuracy: 0.9841 - loss: 0.0394 - val_accuracy: 0.9783 - val_loss: 0.0359
Epoch 26/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 18ms/step - accuracy: 0.9975 - loss: 0.0128 - val_accuracy: 0.9565 - val_loss: 0.0761
Epoch 27/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 17ms/step - accuracy: 0.9882 - loss: 0.0502 - val_accuracy: 1.0000 - val_loss: 0.0223
Epoch 28/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step - accuracy: 0.9899 - loss: 0.0247 - val_accuracy: 0.9783 - val_loss: 0.0280
Epoch 29/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 19ms/step - accuracy: 0.9858 - loss: 0.0256 - val_accuracy: 0.9783 - val_loss: 0.0268
Epoch 30/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 17ms/step - accuracy: 0.9858 - loss: 0.0207 - val_accuracy: 0.9783 - val_loss: 0.0452
Epoch 31/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss: 0.0096 - val_accuracy: 0.9565 - val_loss: 0.0622
Epoch 32/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9882 - loss: 0.0474 - val_accuracy: 1.0000 - val_loss: 0.0117
Epoch 33/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9810 - loss: 0.0441 - val_accuracy: 0.9783 - val_loss: 0.0431
Epoch 34/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss: 0.0133 - val_accuracy: 0.9565 - val_loss: 0.0667
Epoch 35/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9935 - loss: 0.0124 - val_accuracy: 0.9783 - val_loss: 0.0485
Epoch 36/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9925 - loss: 0.0148 - val_accuracy: 1.0000 - val_loss: 0.0176
Epoch 37/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss: 0.0104 - val_accuracy: 0.9783 - val_loss: 0.0385
Epoch 38/50
```

```
Epoch 39/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9964 - loss: 0.0154 - val_accuracy: 1.0000 - val_loss: 0.0215
Epoch 40/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9960 - loss: 0.0107 - val_accuracy: 0.9783 - val_loss: 0.0534
Epoch 41/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9867 - loss: 0.0253 - val_accuracy: 0.9783 - val_loss: 0.0445
Epoch 42/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - accuracy: 0.9949 - loss: 0.0149 - val_accuracy: 1.0000 - val_loss: 0.0212
Epoch 43/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - accuracy: 0.9949 - loss: 0.0086 - val_accuracy: 1.0000 - val_loss: 0.0136
Epoch 44/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - accuracy: 0.9899 - loss: 0.0173 - val_accuracy: 0.9783 - val_loss: 0.0543
Epoch 45/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9927 - loss: 0.0273 - val_accuracy: 0.9783 - val_loss: 0.0309
Epoch 46/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9949 - loss: 0.0129 - val_accuracy: 1.0000 - val_loss: 0.0180
Epoch 47/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9949 - loss: 0.0130 - val_accuracy: 1.0000 - val_loss: 0.0111
Epoch 48/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9914 - loss: 0.0121 - val_accuracy: 0.9783 - val_loss: 0.0298
Epoch 49/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss: 0.0082 - val_accuracy: 0.9783 - val_loss: 0.0411
Epoch 50/50
6/6 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - accuracy: 1.0000 - loss: 0.0135 - val_accuracy: 0.9783 - val_loss: 0.0487
```

Figure3.5.3.6results of the model

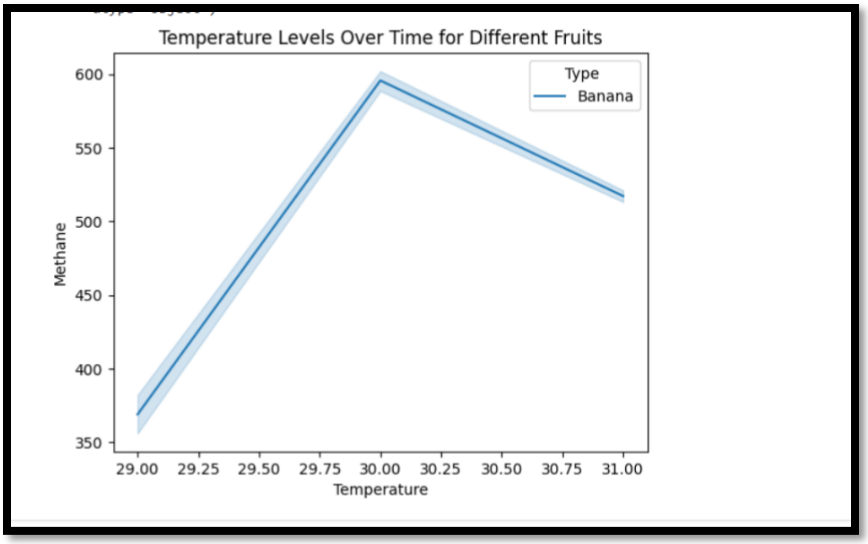


Figure 3.5.3.7 Temperature level

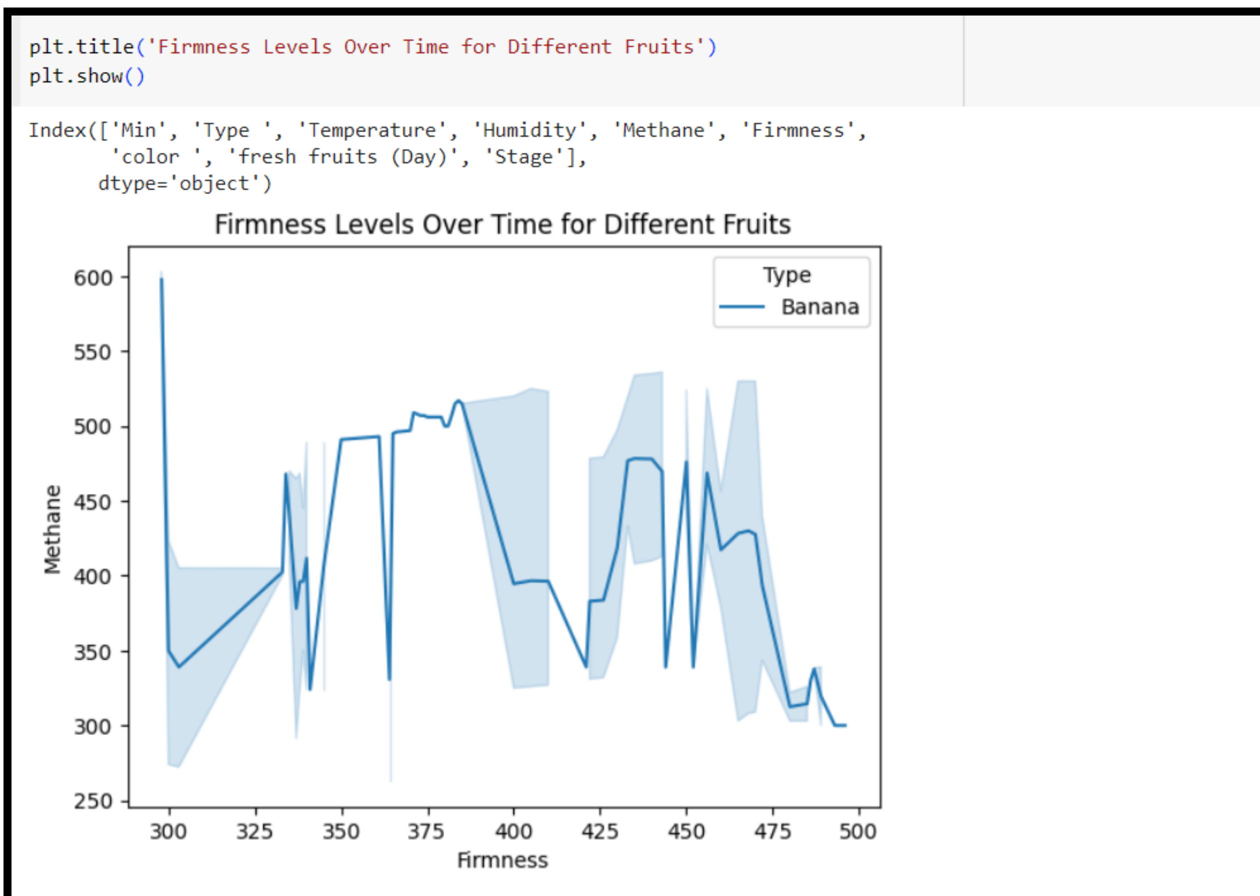


Figure 3.5.3.8 Firmness level

The above images show the effect of firmness and temperature on the methane value. As the methane content increases, so does the temperature. As the methane content increases, the firmness value decreases.

```
[64] # Evaluate the model on the test data
     test_loss, test_acc = model.evaluate(X_test, y_test)

     print(f"Test Accuracy: {test_acc * 100:.2f}%")

     2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step - accuracy: 0.9751 - loss: 0.0558
     Test Accuracy: 97.83%

     # Predict on test set
     y_pred = model.predict(X_test)

     # Convert predictions to class labels
     y_pred_labels = np.argmax(y_pred, axis=1)

     # Calculate accuracy
     accuracy = accuracy_score(y_test, y_pred_labels)
     print(f"Prediction Accuracy: {accuracy * 100:.2f}%")

     2/2 ━━━━━━━━━━━━━━━━━━━━ 0s 73ms/step
     Prediction Accuracy: 97.83%
```

Figurer 3.5.3.9 Test Accuracy

The test accuracy of the developed model was considered to be 97.83 and prediction accuracy was 97.83%.

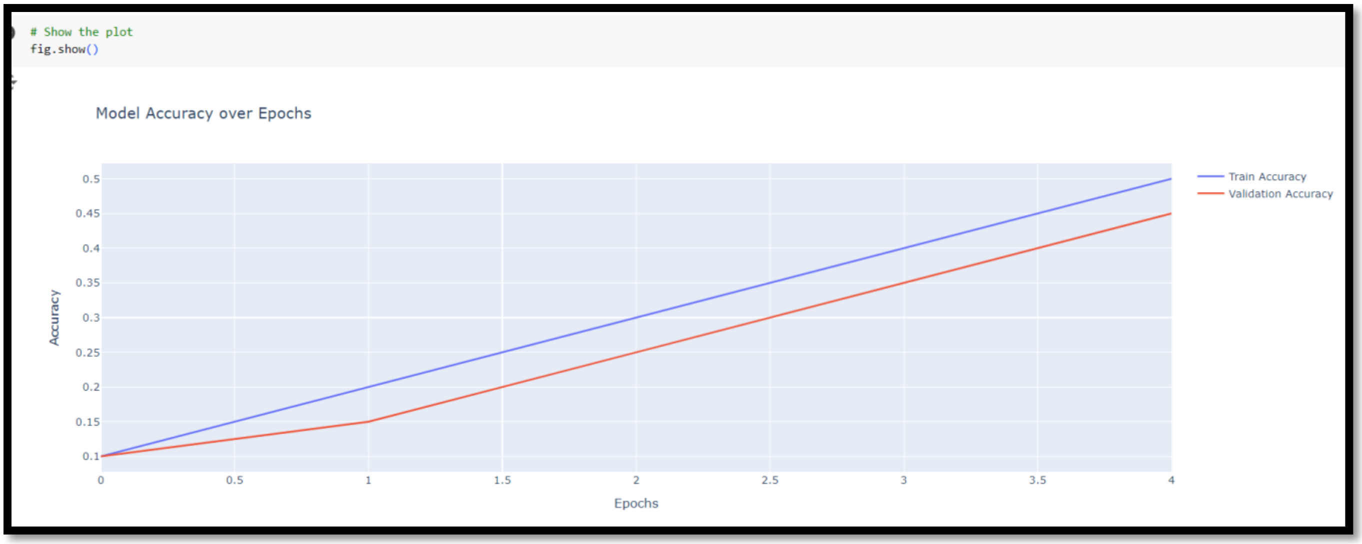


Figure 3.5.3.10 Model accuracy over epochs

With an emphasis on early quality change detection using sensor data, the proposed model evaluates the freshness and ripeness stages of fruits. By feeding in characteristics including methane, temperature, humidity, and texture, the system forecasts freshness and ripeness percentages. Accuracy plots are a useful tool for tracking model learning, identifying overfitting and under fitting, and directing hyper parameter modification to enhance prediction performance.

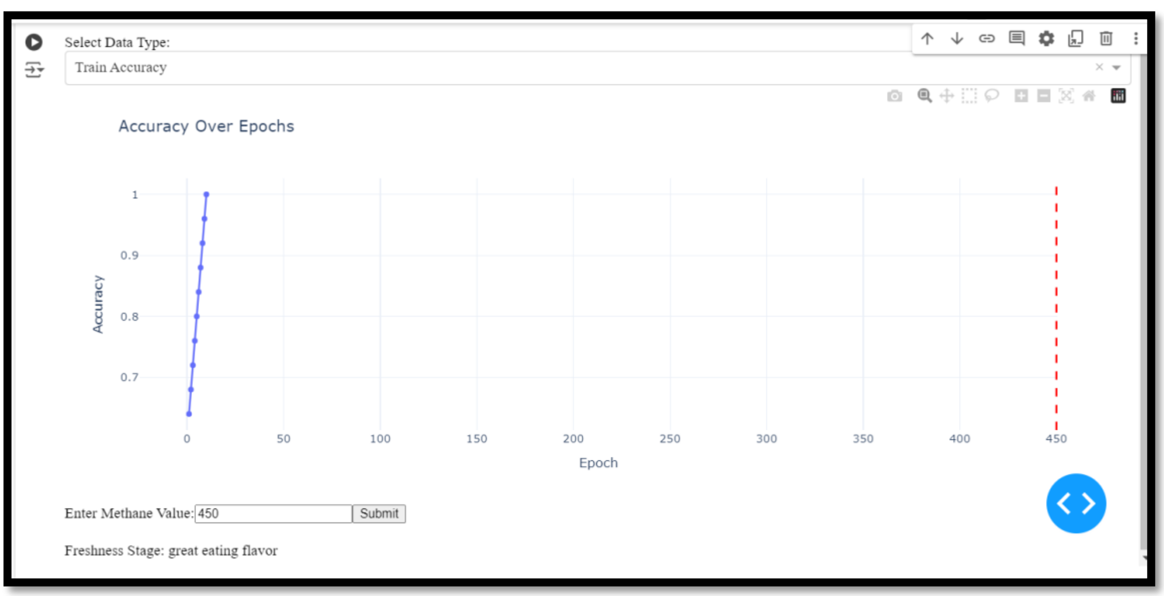


Figure 3.5.3.11 Accuracy over epochs Dashboard

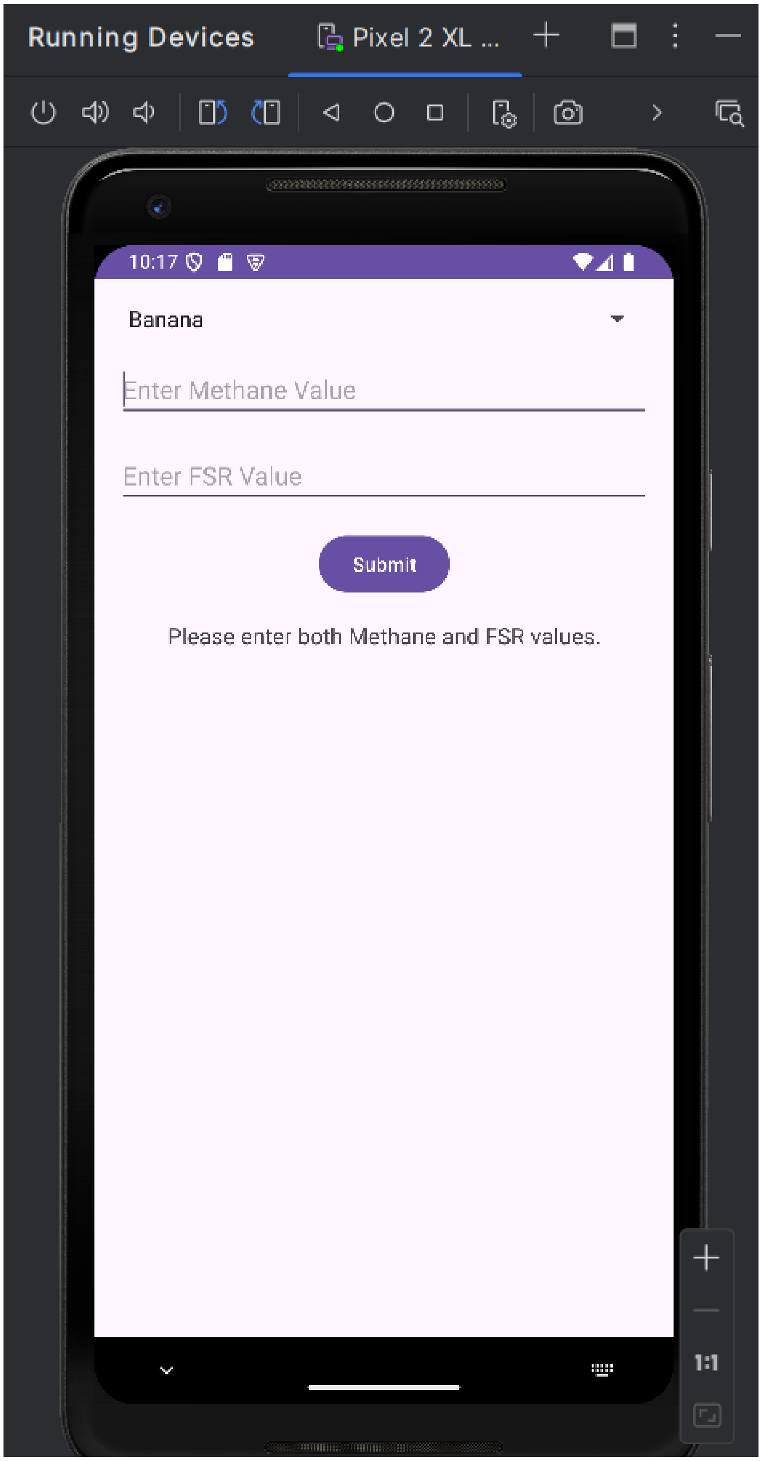


Figure 3.5.3.11 mobile app interface

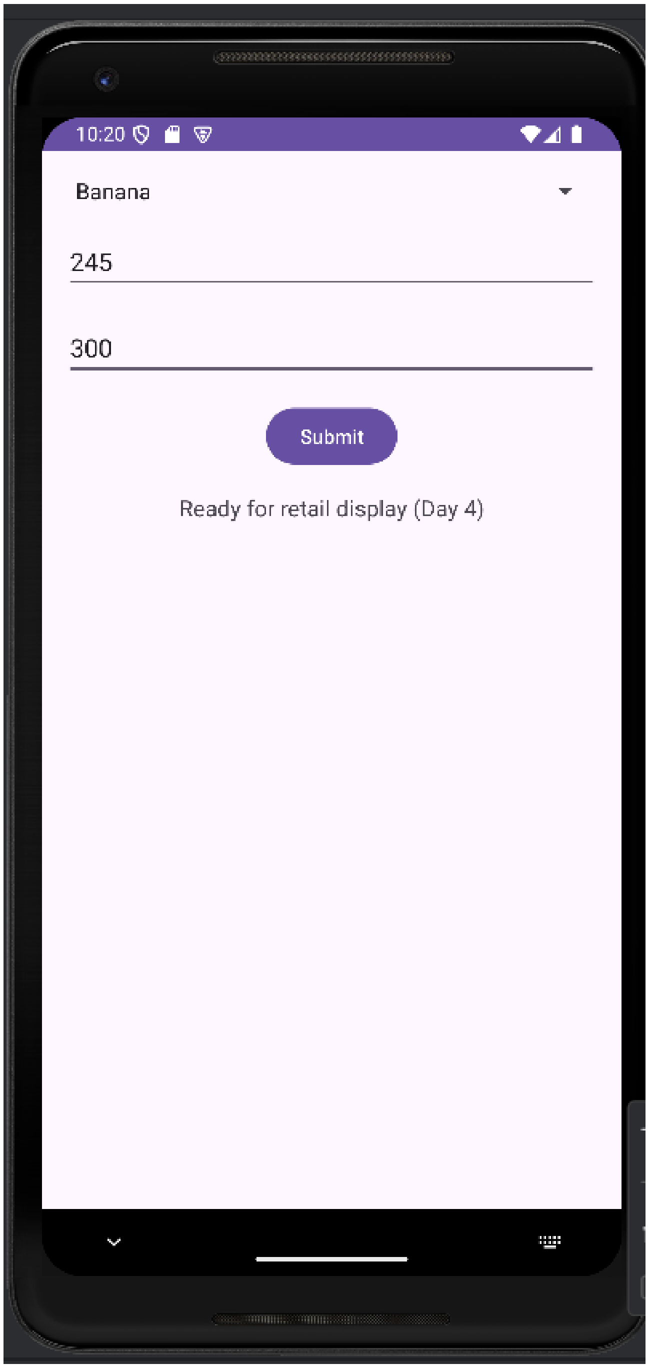


Figure.5.3.12 value enter interface

Analysis of questionnaire https://forms.gle/wVmbmEM1bufrSYu48

Chapter 04 –

4.0Academic Findings:

- **How do sensors detect various data to detect freshness using these parameters such as color, texture, smell, temperature and humidity?**

To prove a system that can assess the quality and freshness of selected fruits for papaya and banana local name (Ambul) /common name (Sour Banana). We need to categorize the fruits into two groups as green and yellow, and test them on four selected days, the day of harvest, three days after harvest, Day2, 5 ,6, and day7, to observe the changes in these four factors (methane, temperature, humidity, and texture). After entering the type of fruit, color, and the in methane, temperature, humidity, and texture after 45 minutes as inputs for the model, the model will predict the freshness of the fruit as a Stage. The quality of the fruits is monitored for early detection of freshness under different environmental using parameters such as gas (methane), firmness, color, temperature and humidity of fruits.

- **How does software algorithm analyses sensors data to determine freshness?**

A Software algorithm analyses sensor data to determine freshness evaluating fruits quality through IOT based solution. The collected data were used to train the machine learning model (CNN) these collected data was used to train the machine learning model (Keras Sequential Model). By entering the type of fruit's gas (methane), firmness, color, temperature, and humidity as inputs, the model predicts the freshness of the fruit and its ripeness stage.

- **How to determine and sells at the right times for fruits?**

After entering the type of fruit, color, and the of the methane, temperature, humidity, and texture (FSR sensor), after 45 minutes as inputs for the model, it will predict the freshness of the fruit as a Stage. A software algorithm analyzes sensor data to determine fruit freshness using to train a CNN model for quality evaluation. By entering the type of fruit and the difference in gas (methane), firmness, color, temperature, and humidity as inputs, the model predicts the freshness of the fruit and its ripeness stage.

4.2 Sample Code

(1) showed the and temperature humidity and the release used Methane gas

```
#include <dht.h>
dht fruits;
void setup() {
  Serial.begin(9600);
  pinMode (A0,INPUT);

}
  float val;

void loop(){
  int val= fruits.read11(7);
  Serial.print("temperature = ");
  Serial.print(fruits.temperature );
  Serial.print("\t Humidity = ");
  Serial.print(fruits.humidity);
  val=analogRead(A0);
  Serial.print("\t methane = ");
  Serial.println(val);
  delay(1000);

 }
```

(2) check values use if condition

```
#include <dht.h>
dht fruits;
void setup() {
  pinMode (A0,INPUT);
  pinMode (8,OUTPUT);
  Serial.begin(9600);
}
  float val;

void loop(){
  int val= fruits.read11(7);
  Serial.print("temperature = ");
  Serial.print(fruits.temperature );
  Serial.print("\t Humidity = ");
  Serial.print(fruits.humidity);
  val=analogRead(A0);
  Serial.print("\t methane = ");
  Serial.println(val);
  if(A0 < 468){
   digitalWrite(8,HIGH);
   Serial.println("FRSH FRUITS" );
   delay(1000);
  }
  else
{
   digitalWrite(8,LOW);
}
```

```
}
```

(3) Check values and otherwise showed more than 7 days

```
#include <dht.h>
dht fruits;
void setup() {
  pinMode (A0,INPUT);
  pinMode (8,OUTPUT);
  Serial.begin(9600);
}
  float val;

void loop(){
  int val1= fruits.read11(7);
  Serial.print("temperature = ");
  Serial.print(fruits.temperature );
  Serial.print("\t Humidity = ");
  Serial.print(fruits.humidity);
  val=analogRead(A0);
  Serial.print("\t methane = ");
  Serial.println(val);
  if(val > 300){
   digitalWrite(8,HIGH);
   Serial.println("FRSH FRUITS day7" );
   delay(1000);
  }
   else{
     digitalWrite(8,LOW);
  }
    if(val > 360){
   digitalWrite(8,LOW);
   Serial.println("day7" );
   delay(1000);

  }
  else {
     digitalWrite(8,LOW);
  }
}
```

(4)FSR sensor value read

```
#include <dht.h>


dht fruits;
```

```
void setup() {
  pinMode(A0, INPUT);    // Methane sensor
  pinMode(A1, INPUT);    // FSR sensor
  pinMode(8, OUTPUT);    // LED output
  Serial.begin(9600);
}

float methaneVal;
float fsrVal;

void loop() {
  // Read temperature and humidity from DHT sensor
  int val1 = fruits.read11(7);
  Serial.print("Temperature = ");
  Serial.print(fruits.temperature);
  Serial.print(" °C\t Humidity = ");
  Serial.print(fruits.humidity);
  Serial.println(" %");

  // Read methane sensor value
  methaneVal = analogRead(A0);
  Serial.print("Methane = ");
  Serial.println(methaneVal);

  // Read FSR sensor value
  fsrVal = analogRead(A1);
  Serial.print("FSR (Firmness) = ");
  Serial.println(fsrVal);
```

```
// Logic based on methane sensor value
if (methaneVal > 300) {
  digitalWrite(8, HIGH);
  Serial.println("FRESH FRUITS (Day 7)");
  delay(1000);
} else {
  digitalWrite(8, LOW);
}

if (methaneVal > 360) {
  digitalWrite(8, LOW);
  Serial.println("FRUITS ROTTING (Day 7)");
  delay(1000);
} else {
  digitalWrite(8, LOW);
}

// Additional logic for FSR sensor
// can set thresholds for firmness:
if (fsrVal < 200) {
  Serial.println("Fruit is soft (Overripe)");
} else if (fsrVal >= 200 && fsrVal <= 600) {
  Serial.println("Fruit is firm (Fresh)");
} else {
  Serial.println("Fruit is very firm (Unripe)");
}
```

```
  delay(2000); // Delay before the next loop iteration
}
```

Read Fruit's Stage

```
#include <dht.h>

// DHT sensor setup
dht fruits;

// TCS3200 sensor pins
const int S0 = 4;
const int S1 = 5;
const int S2 = 6;
const int S3 = 7;
const int sensorOut = 8;  // Frequency output pin

void setup() {
  // Pin setup for methane sensor and FSR sensor
  pinMode(A0, INPUT);    // Methane sensor
  pinMode(A1, INPUT);    // FSR sensor

  // Pin setup for TCS3200 sensor
  pinMode(S0, OUTPUT);
  pinMode(S1, OUTPUT);
  pinMode(S2, OUTPUT);
  pinMode(S3, OUTPUT);
  pinMode(sensorOut, INPUT);

  // Set frequency scaling to 20%
  digitalWrite(S0, HIGH);
```

```
  digitalWrite(S1, LOW);

  // Start serial communication
  Serial.begin(9600);
}

float methaneVal;
float fsrVal;
int redFreq, greenFreq, blueFreq;

void loop() {
  // Read temperature and humidity from DHT sensor
  int val1 = fruits.read11(7);
  Serial.print("Temperature = ");
  Serial.print(fruits.temperature);
  Serial.print(" °C\t Humidity = ");
  Serial.print(fruits.humidity);
  Serial.println(" %");

  // Read methane sensor value
  methaneVal = analogRead(A0);
  Serial.print("Methane = ");
  Serial.println(methaneVal);

  // Read FSR sensor value
  fsrVal = analogRead(A1);
  Serial.print("FSR (Firmness) = ");
  Serial.println(fsrVal);

  // Read color data from TCS3200 sensor
```

```
// Red
digitalWrite(S2, LOW);
digitalWrite(S3, LOW);
redFreq = pulseIn(sensorOut, LOW);

// Green
digitalWrite(S2, HIGH);
digitalWrite(S3, HIGH);
greenFreq = pulseIn(sensorOut, LOW);

// Blue
digitalWrite(S2, LOW);
digitalWrite(S3, HIGH);
blueFreq = pulseIn(sensorOut, LOW);

Serial.print("Red = ");
Serial.print(redFreq);
Serial.print("\tGreen = ");
Serial.print(greenFreq);
Serial.print("\tBlue = ");
Serial.println(blueFreq);

// Detect Yellow
if (redFreq < 1000 && greenFreq < 1000 && blueFreq > 1500) {
  Serial.println("Fruit is YELLOW");
}
// Detect Green
else if (greenFreq < redFreq && greenFreq < blueFreq) {
  Serial.println("Fruit is GREEN");
}
```

```
// Detect other colors (red, blue, etc.)
else if (redFreq < greenFreq && redFreq < blueFreq) {
  Serial.println("Fruit is RED (Possibly ripe)");
} else if (blueFreq < redFreq && blueFreq < greenFreq) {
  Serial.println("Fruit is BLUE (Overripe or damaged)");
} else {
  Serial.println("Unknown fruit color");
}

// Logic based on methane sensor value
if (methaneVal > 300) {
  Serial.println("FRESH FRUITS (Day 7)");
  delay(1000);
} else {
  Serial.println("FRUITS STABLE");
}

if (methaneVal > 360) {
  Serial.println("FRUITS ROTTING (Day 7)");
  delay(1000);
}

// Logic for FSR sensor (firmness)
if (fsrVal < 200) {
  Serial.println("Fruit is soft (Overripe)");
} else if (fsrVal >= 200 && fsrVal <= 600) {
  Serial.println("Fruit is firm (Fresh)");
} else {
  Serial.println("Fruit is very firm (Unripe)");
}
```

```
  delay(2000);  // Delay before next loop iteration
}
```

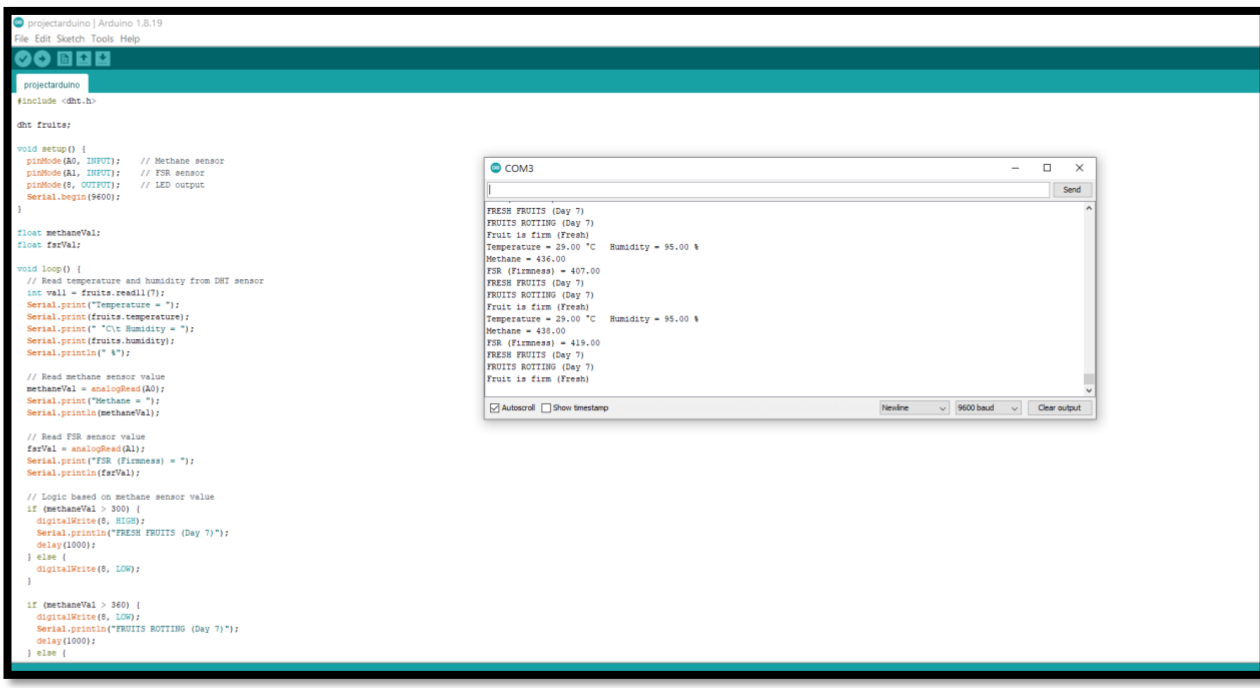
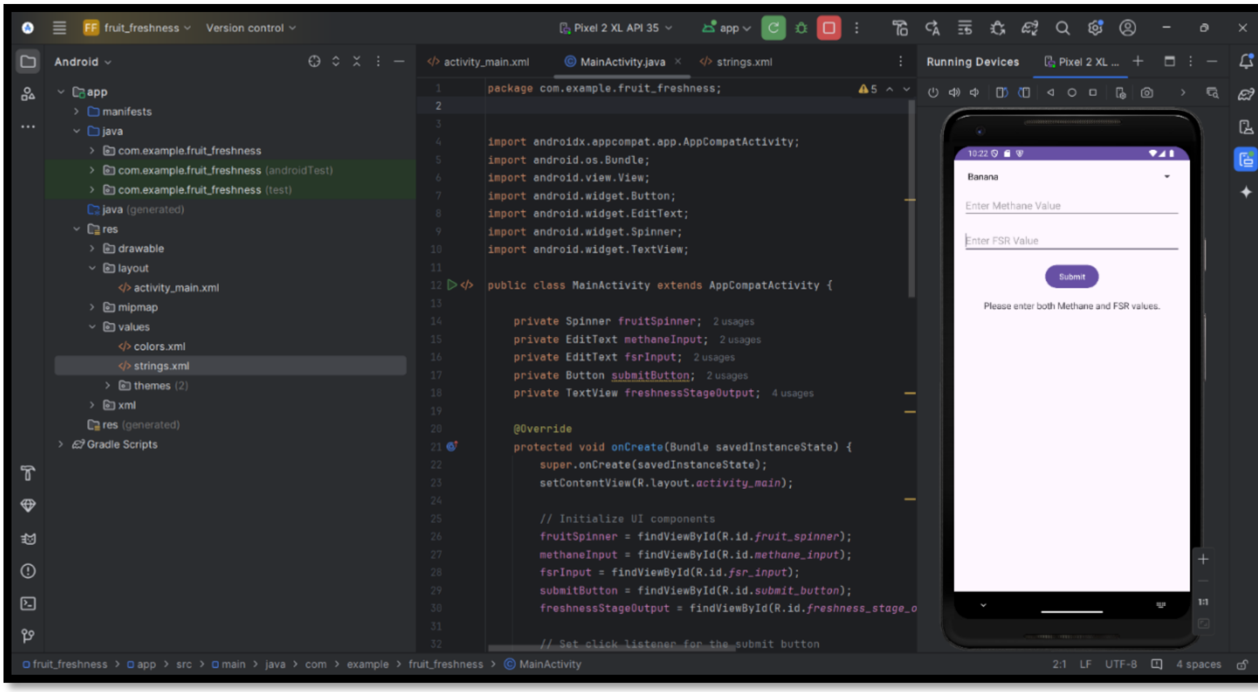


Figure.2. Arduino code



4.3 Test Cases

data collected fruits as banana, papaya, mango and tomato with get this values the values of the harvested fruits are obtained at the time when the fresh fruits are harvested, when there is a slight green mixture.

- Start humidity
- Start temperature
- Start methane value
- Get this values day1, day3, day7
- set values for freshness
- Currant Stage

Use cases: Buying, packing, storage of fruit

Table 2: 4.3.1 – Test Case

Test Case Identifier	01
Test Case	Input values (banana)
Test Designed by	Meththani uthpala
Test Designed Date	2024.8.8
Test Executed by	Meththani Uthpala
Test Executed Date	2024.8.8

Description	To know the freshness of fruit, get an understanding of the current Stage and date via dashboard				
Pre-Condition	Need enter methane value				
Test Case #	Sequence #	Test Case Description	Test Data / Input Value(s)	Expected Result	Status (day/more thane)
	1.1	Value is higher than day5	Methane value:	Fruit fresh Day 5/6	great eating flavor
		Value is higher than day6	Methane value:	(Day7)	Start spoil
Description:	To know the freshness of fruit, get an understanding of the current Stage and date via mobile app				
Pre-Condition	Need enter methane & FSR value				
	1.2	Value is higher than day day3	Methane value and FSR value	Fruit fresh Day 4	ready for retail display

<u>1.1 OUTPUT RESULT:</u>

Figure 8:4.3.1 : 1.1 result

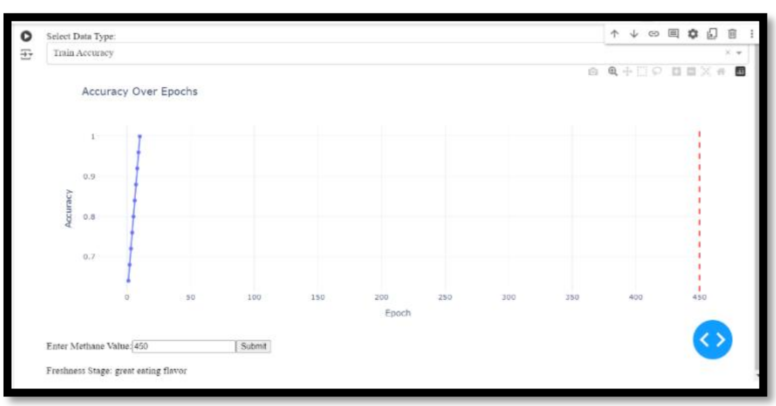


Figure.4.3.1.1 Dashboard output

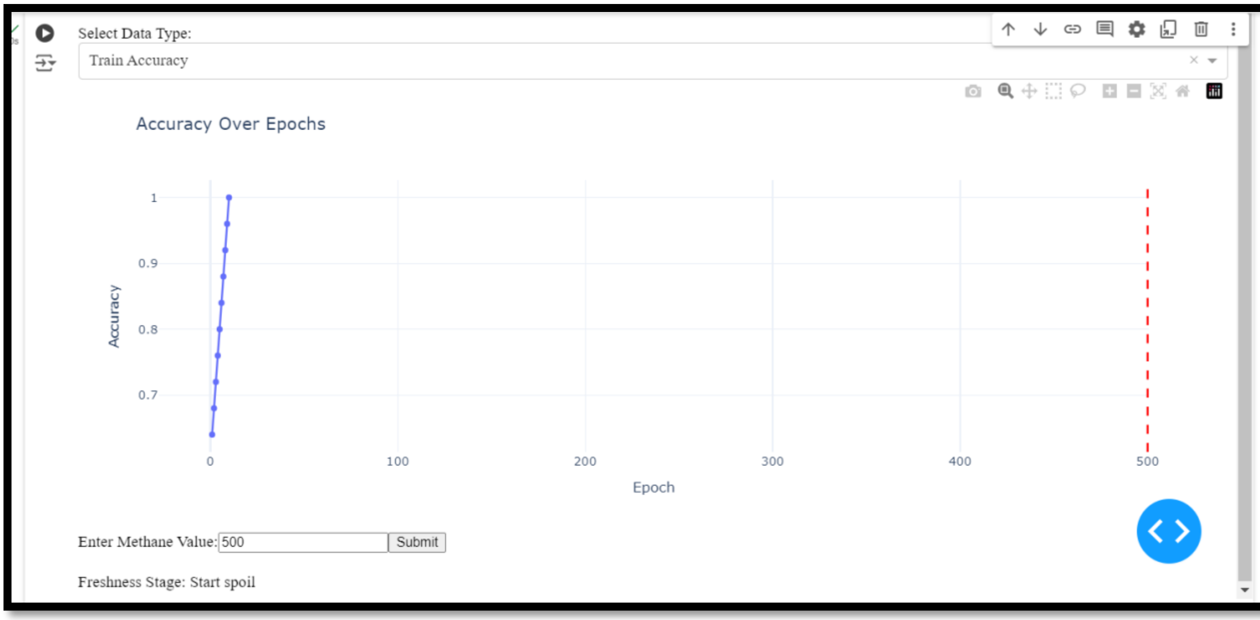


Figure 4.2.1 spoil fruit output

Figure:4.3.2: 1.1 result

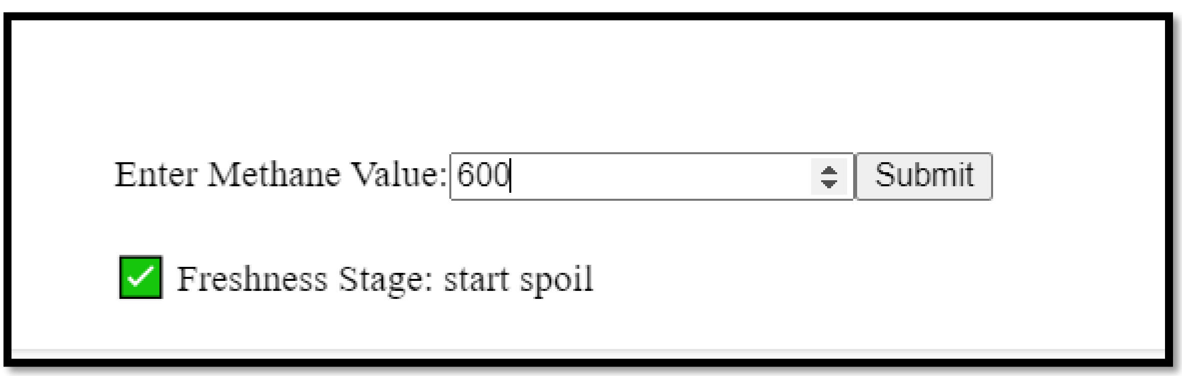


Figure 4.3.1.1 result

1.2 OUTPUT RESULT:

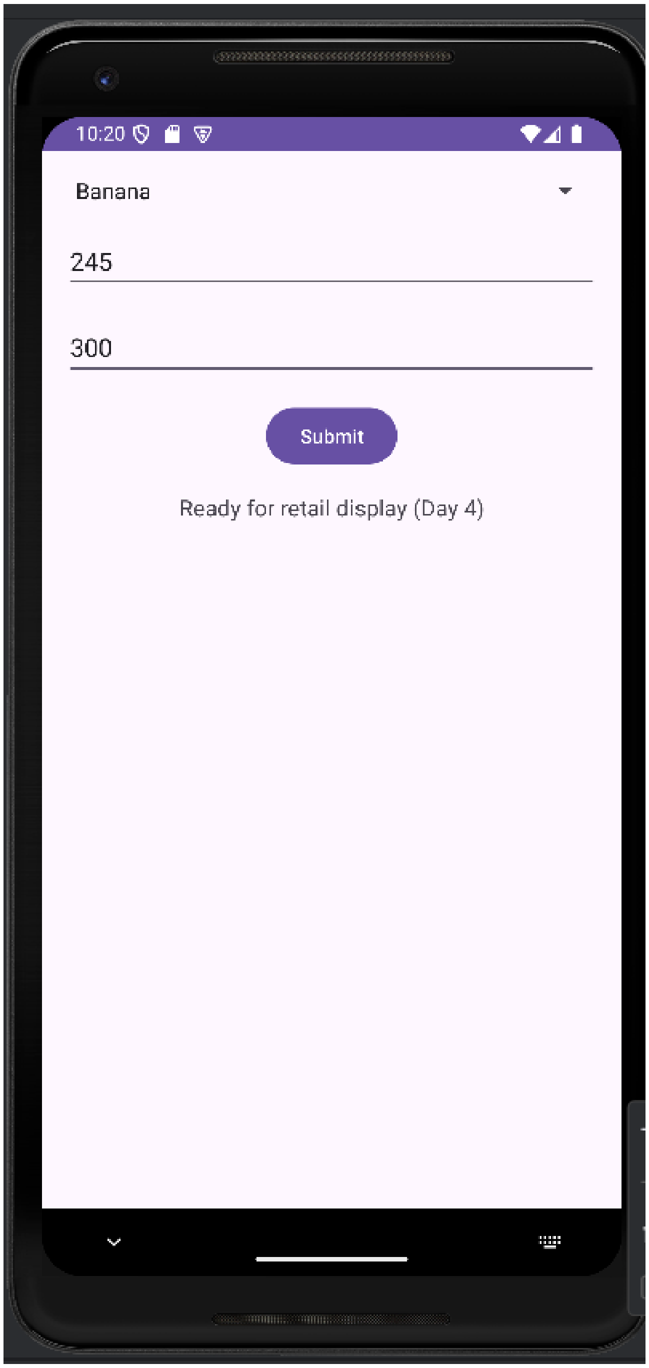


Figure 1.2. Result

Chapter 05 – Conclusion

5.1Important Outcome

Survival period of the fruits after harvest is relatively short Then, the values of the harvested fruits are obtained at the time when the fresh fruits are harvested, when there is a slight green mixture. Main objective of this research is to measure the freshness of fruits by observing their CO2 release, humidity release and temperature after harvesting for the banana, papaya tested in days including the harvested day, three days after harvest, a week after, and 1, 2,3,4,5,6, 7 days after to observe the changes in these three factors (CO2, temperature and humidity, Firmness). CO2 sensor, and a humidity sensor was set up to detect the changes. After 45 minutes, as inputs for the model, the model will predict the set value from what we want freshness of the fruit as a Stage.The collected data were used to train the machine learning model (CNN) these collected data was used to train the machine learning model (Keras Sequential Model). By entering the type of fruit's gas (methane), firmness, color, temperature, and humidity as inputs, the model predicts the freshness of the fruit and its ripeness stage.

5.2 Limitation

It may occasionally be impacted in any way by storage or chemical alterations that occur within these fruits and vegetables. To keep food from rotting in a variety of environmental conditions, such as temperature, humidity, and fruit/vegetable characteristics, the quality of the food should be verified. It will be useful for checking food quality using various techniques. A sensor detects changes in food color. I receive this data only after five days and I determine its freshness after seven days. Even if there isn't a color change after seven days, this was made under the assumption that storage does not affect the color. Depending on the crop's maturity and kind, harvesting is the first step in the process of gathering crops from the fields. In this action Stowing Following cleaning and sorting, the crops are placed in containers meant for transportation, albeit the exact type of container used will depend on the crop's intended shelf life. The Accuracy of the developed model was considered to be 97.83.

5.3 Critical Evaluation

measuring the temperature, humidity, and CO2 concentration and firmness for few fruits, including papaya and banana and were tested using the developed model. The temperature, humidity, and release of methane gas using the Methane Gas Sensor MQ-4, the Temperature and Relative Humidity Sensor DHT11, and the FSR sensor, were all clearly displayed in the data that was gathered.

Between the harvest date and the dates of packing, storing, shipping, and selling

Crops are first removed from the fields during the harvesting stage, which varies depending on the crop's maturity and kind.

Solution: information gathered from fruits like bananas and papayas obtain these values
This stage involves packing Following cleaning and sorting, the crops are placed in containers meant for transportation, albeit the exact type of container used will depend on the crop's intended shelf life.

solution:
Obtain these values for days 1, 3, and 7, then set the freshness values.
The right storage conditions are essential to preserving the freshness of fruits and vegetables, and they differ based on the method used (e.g., chemicals).
Transport and storage options vary based on the kind of fruits and vegetables. Sales and retiling:

The solution is to create new online marketplaces where consumers may buy fruits and vegetables from farmers' markets or retail establishments.

5.4 Future Work

The system can integrate additional sensors and methods, such as nanotechnology, to improve results even further. For example, it can calculate its NDVI by comparing the data from an IR sensor and a gas sensor, and then displaying the results on the screen.

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Appendix

Questionnaire A

1.Name

2.Email

3.Gender

- Male
- Female

4.Age

- 20-25
- 25-45
- 45-65
- >65

5.Do you know that you can prevent crop damage after knowing before vegetables and fruits spoil?

- Yes
- No

6.Are you a person who grows vegetables and fruits for home?

- Yes
- No

7.If yes, Location of Farm?

- Kurunegala
- Monaragala
- Rathnapura
- Kaluthara
- Badulla

8.Farming and Marketing experience (Year)

- <5
- 5-15
- 10-25
- >25

9.Education level of marketers

- No formal education
- Primary Secondary
- Tertiary

10.Information source for what do you use

- Media
- Government
- Farmers community
- Private sectors
- Others

11.How you get financial support for your farming and marketing

- Government bank
- Farmers association
- Private sectors/NGO
- Individual lender
- Other

12.Education level of farming and marketing

- No formal education
- Primary
- Secondary
- Tertiary

13. What is the name of your province?

14Are the vegetables and fruits you get fresh and are you aware of the time it takes to spoil?

- Yes
- No

15. Where do you get the vegetables and fruits you need at home?

Small Farms and home gardens

• Cluster organizations / Commercial farms
• Agro zone project and Integrated agriculture projects
• Village / Central collecting centres

16.Is it convenient for you to know if the vegetables and fruits you get are fresh and if they are spoiled?

Yes

No

17.

Would it be convenient for you if you could know whether the vegetables and fruits you get are fresh and how long it takes to spoil?

- Yes
- No

18.What method have you used before to know whether vegetables and fruits are fresh?

19.How long will it take you to get the vegetables and fruits you need for the house?

- daily
- day to day

Appendices B

Informant interviews

A. Field participants

Name	Title	Date	Time
Midigama Fruit Farm's supervisor	ecological farm's fresh produce is collected by their farm gate shop	2024. 3. 3	15min
5 staff employee selected in randomly	Detection system need or don't with ideas	2024 .3 3	15min

Interview Guide for participants

The main purpose of this study is to develop a computerized fruits freshness detection system that will help in monitoring clients' satisfaction and efficiently as they move through various processes of their requests.

1. What method have you used before to know whether vegetables and fruits are fresh
……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………………
2. … How long will it take you to get the vegetables and fruits you need for the house?……………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………………

3. Would you like to have an freshness system method to know whether the vegetables and fruits you get are fresh and perishable?
....
....
....

4. What steps do you take to made in processing a particular client's request when?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………

5. Do you think a computerized system would ease the process of establishing the progress made in processing a client's request? If so, explain.

....
....