IntelliCART (AI Enabled Smart Cart)

PROGRESS REPORT BS(CS) 2023

PROJECT TEAM

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Introduction

1. Background

The modern agricultural industry has evolved remarkably with technological advancements. This leads to growing interest in using computer vision and deep learning techniques to various aspects of agriculture such as farming and supple chain. Fruits contain vitamins and dietary fibers, a vital source of the human die. The quality assessment of fruits and vegetables results a critical factor for both seller and customers. Traditionally the assessment of fruits and vegetable quality heavily relies on experienced manual labor inspection which is time consuming, subjective, and often prone to errors. This way of assessment also results in maintaining consistency, and scalability especially in large scale operations. The emergence of innovative technologies particularly in field of Artificial Intelligence, Machine Learning, and Computer Vision has introduced a way of to revolutionize the assessment of fruits and vegetables. This offer potential to automate and streamline the assessment process, ensuring high accuracy, and scalability.

2. Importance of Fruit Quality Assessment

In today's marketplace, the fruits and vegetable quality assessment holds immense importance across various domains including customer satisfaction and preferences, ensuring food safety and health, and impacting economy significantly.

2.1 Consumer Preferences and Expectations

Consumer expects fresh, visual appealing, best quality fruits and vegetable when making their purchases. Thus quality assessment plays an important role in meeting these expectations as it provides consumer with satisfaction regarding overall condition of fruits and vegetables. The quality of fruits and vegetable impact consumer perception of values. Fruits and vegetable that are fresh and have high quality tend to fetch better prices and are preferred by customers resulting in increased sales and customer satisfaction. Delivery of high quality fresh produce results in customer loyalty and repeat business. When customers trust the quality of fruits and vegetable purchased they more likely to return to same seller.

2.2 Impact on Food Safety and Healthy

Fresh and high quality fruits and vegetables holds more nutrients contributing to better health outcomes. Poor quality, contaminated or spoiled poses great risk and threat to health of customers. Effective high quality assessment helps in segregating such risks. Thus results in safety from risks caused by consuming low quality fruits and vegetables.

2.3 Economic Significance

High quality fruits and vegetables results in better marketability and prices. Venders selling high quality fruits and vegetable attract more customers and can sell them at good rates resulting in good revenue. Effective quality assessment contributes to more efficient supply chain. By accurately assessing quality it can streamline distribution, reduce inventory holding costs and ensures quality items reach the consumer. Improved quality assessment

practices lead to more feasible agriculture practices, improved profitability for sellers and better resource utilization.

3. Challenges in Fruit Quality Assessment

The assessment of fruits and vegetable quality presents several challenges impacting the efficiency and accuracy of evaluation. These challenges include subjectivity in assessment, time consuming and labor intensive highlighting the importance for more objective and efficient solutions.

3.1 Subjectivity and Variability

Traditional methods of fruit and vegetable quality assessment relied on human assessment which is subjective. Difference individual may have different judgement and assess quality differently resulting inconsistent grading and classification. Standards of assessing quality can differ across regions, markets and cities. This difference complicates standardization of assessment criteria and results variation in quality evaluation. Fruits and vegetable have natural variation in color, size texture and other attributes making it challenging for establishing standardized criteria for quality assessment.

3.2 Time and Labor Intensive

Traditional methods involve manual inspection which is time consuming and requires more workforce for large scale operations. This involve sorting, grading each fruit individually leading to time wastage, labor costs and operational difficulties. In areas such as markets the manual assessment of large quantity of fruits and vegetable becomes impractical and not efficient resulting in bottlenecks and delays.

3.3 Need for Objective and Efficient Solutions

With increased demand for high quality fruits and vegetables there is need for standardized methods that can ensure unanimous quality assessment across different markets. The market demands real time evaluation of quality of fruits and vegetable minimize delays in distribution and ensure fresh fruits and vegetables reaching consumers. Manual methods fall short in meeting these demands. Using technological advancement such as machine learning, artificial intelligence and computer vision can result in promising solutions for efficient and automated quality assessment These technologies have potential to standardized assessment criteria and reduce human subjectivity.

4. Role of Computer Vision and Deep Learning

In agriculture sector the integration of computer vision and deep learning technologies provide transformative solution for fruits and vegetable quality assessment. These technologies provide approach for automation, precision, improved efficiency and accuracy resulting in showing immense potential for integration with industry. The latest advanced computer vision technology with the utilization of deep neural networks can be used for object discovery and semantic picture division.

4.1 Automation and Precision

Computer vision provides a way to automate analysis of images of fruits and vegetables allowing for processing large quantity. From that algorithms can identify and extract relevant features such as color, texture, size and defects without human input. By using defined algorithms and computer vision systems we can facilitate standardized evaluation methods minimizing subjectivity. Deep learning models trained on extensive dataset can accurately classify fruits and vegetables based on quality parameters. These models can differentiate between differences in quality such as ripeness, blotch or bruised with high accuracy.

4.2 Enhancing Efficiency and Accuracy

Computer vision system equipped with deep learning models can process images at high speed reducing time for quality assessment. Rapid processing enhances efficiency of assessment process. Deep learning models continuously learn and adapt on data leading to improved accuracy over time. As these models are trained on diverse dataset they can accurately identify and classify a wide range of quality parameters that cannot be done through human capabilities.

4.3 Potential for Industry Integration

Integrating computer vision system into fruits and vegetables supply chain can optimize various stages from production to distribution. Real time quality assessment allows timely assessing quality and ensuring delivery of high quality fruits and vegetables to customers. Beyond traditional markets computer vision and deep learning find application in different sectors including precision agriculture, food processing industries and online retail. These technologies enable quality assessment resulting evolving consumer demands

Timeline

In FYP-I, we done with following phases:

Timeline	Phases	Team Roles
Month 1	Literature Review	Ahad, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 2	Data Collection	Ahad, Basil, Jodat, Dr. Farrukh
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 3	Feature Extraction	Ahad, Basil
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 4	Deep Learning Model	Ahad, Jodat, Basil

Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)

Current Progress and Deliverables

Deliverable 1

Show details of every dataset Clearly show performance of each models on each dataset

Table 1 Datasets

	Data Source	Data Size (no. Of images)		No. Of classes	MobileNet Results (Accuracy)	Inception-V3 Results (Accuracy)	VGG19 Results (Accuracy)	AlexNet Results (Accuracy)	Reference
		Train	Test						
1	IEEE_DataPort - FruitGB	5890	1417	6	98.3%	99.0%	99.01%	87.58%	1
2	Kaggle - Fruits and Vegetables dataset	4804	1196	10	95.22%	92.79%	89.85%	81.14%	2
3	Mendeley - FruitNet	5914	1474	9	97.49%	97.35%	96.94%	92.33%	3
4	Mendeley - VegNet	3982	992	8	96.27%	94.15%	91.73%	77.01%	4
5	Dataset Camera	2108	525	6	99.81%	97.90%	99.42%	99.04%	5
6	Mendeley - Fresh and Rotten Fruits	4594	1146	6	98.19%	99.26%	97.86%	61.24%	6

Classes selected from each Dataset:

1- IEEE_DataPort – FruitGB

['Apple_healthy','Apple_rotten','Banana_healthy','Banana_rotten',
'Orange_healthy','Orange_rotten']

2- Kaggle - Fruits and Vegetables dataset

['Apple_fresh','Apple_rotten','Banana_fresh','Banana_rotten','Orange_fresh','Orange_rotten','Potato_fresh','Potato_rotten','Tomato_fresh','Tomato_rotten']

3- Mendeley – FruitNet

['Apple_healthy','Apple_mixedQuality','Apple_rotten','Banana_healthy','Banana_mixedQuality','Banana_rotten', 'Orange_healthy','Orange_mixedQuality','Orange_rotten']

4- Mendeley - VegNet

['GreenChilli_damaged','GreenChilli_dried','GreenChilli_old','GreenChilli_ripe','Tomato_damaged','Tomato_old','Tomato_ripe','Tomato_unripe']

5- Dataset Camera

['Apple_Healthy', 'Banana_SlightlyBruised', 'Orange_Greening', 'Orange_Healthy', 'Orange_Rotten', 'Tomato_Healthy']

6- Mendeley - Fresh and Rotten Fruits

['Apple_Fresh', 'Apple_Rotten', 'Banana_fresh', 'Banana_Rotten', 'Orange_Fresh', 'Orange_Rotten]

Deliverable 2

Application Design

1. Opening Application

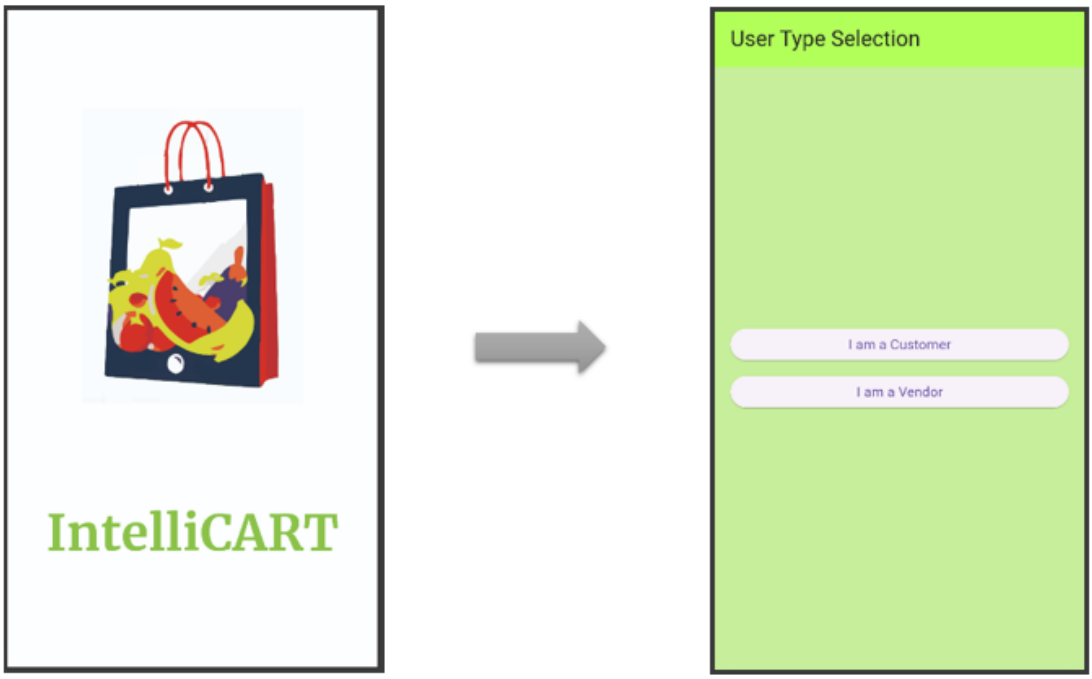

Figure 1 Splash Screen and User Type Selection Screen

2. Vendor Side

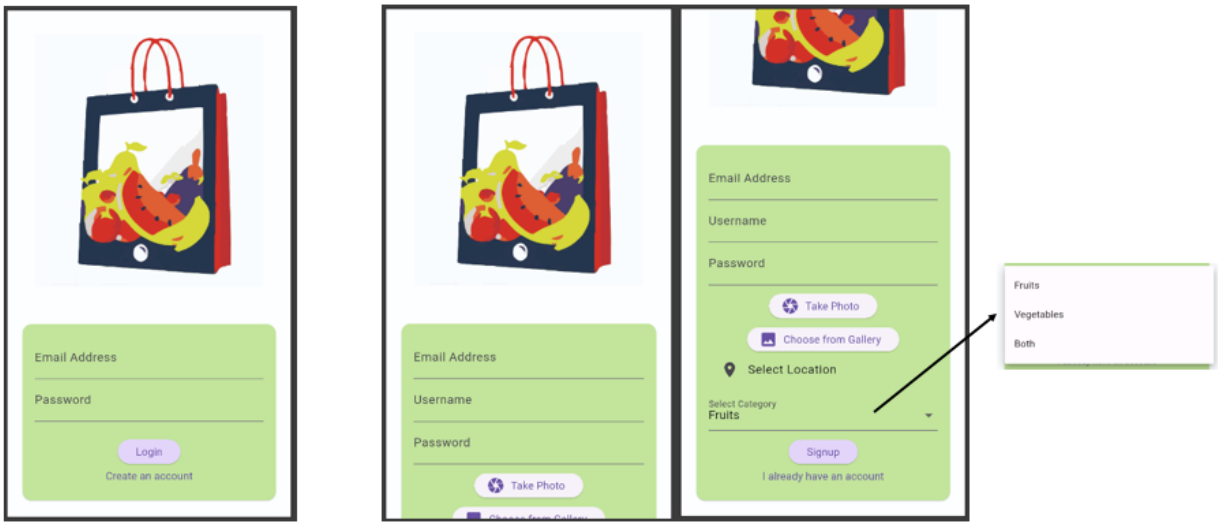

Figure 2 Vendor Registration and Login Screen

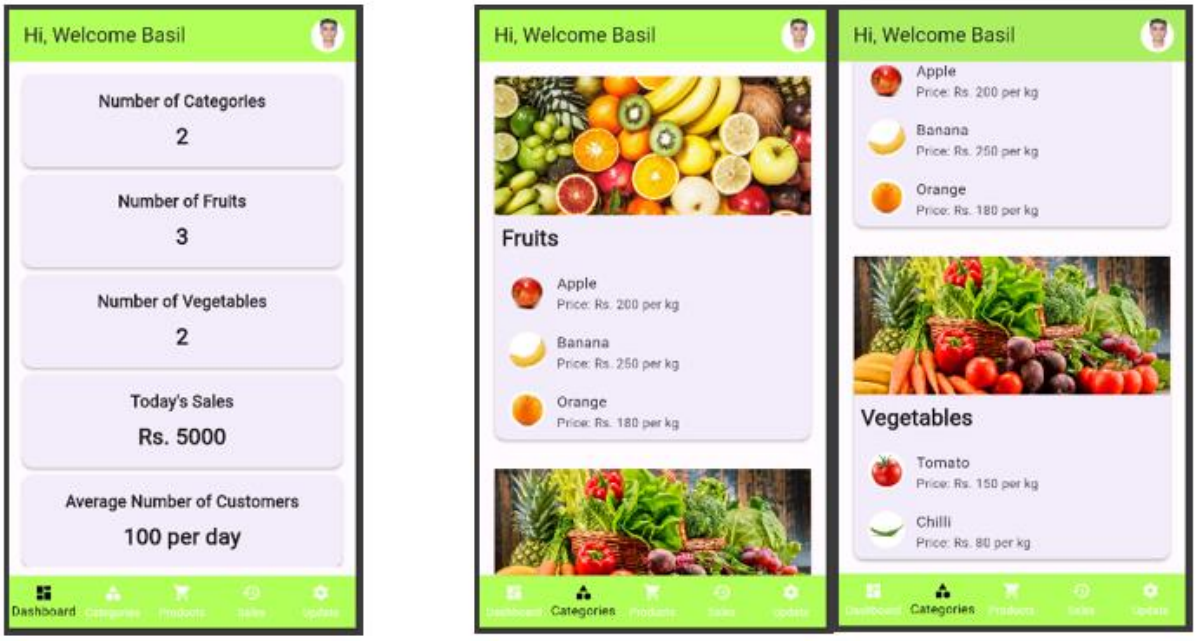

Figure 3 Vendor Dashboard and Categories Screen

Figure 4 Vendor Products Screen

Figure 5 Vendor Sales Screen

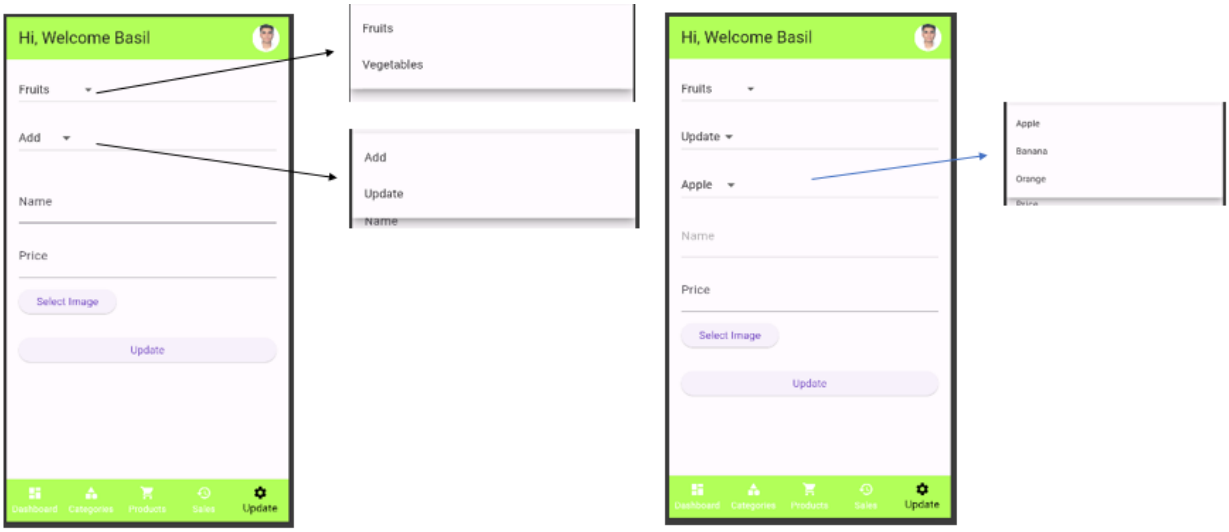

Figure 6 Vendor Add and Update Products Screen

3. Customer Side

Figure 7 Customer Registration and Login Screen

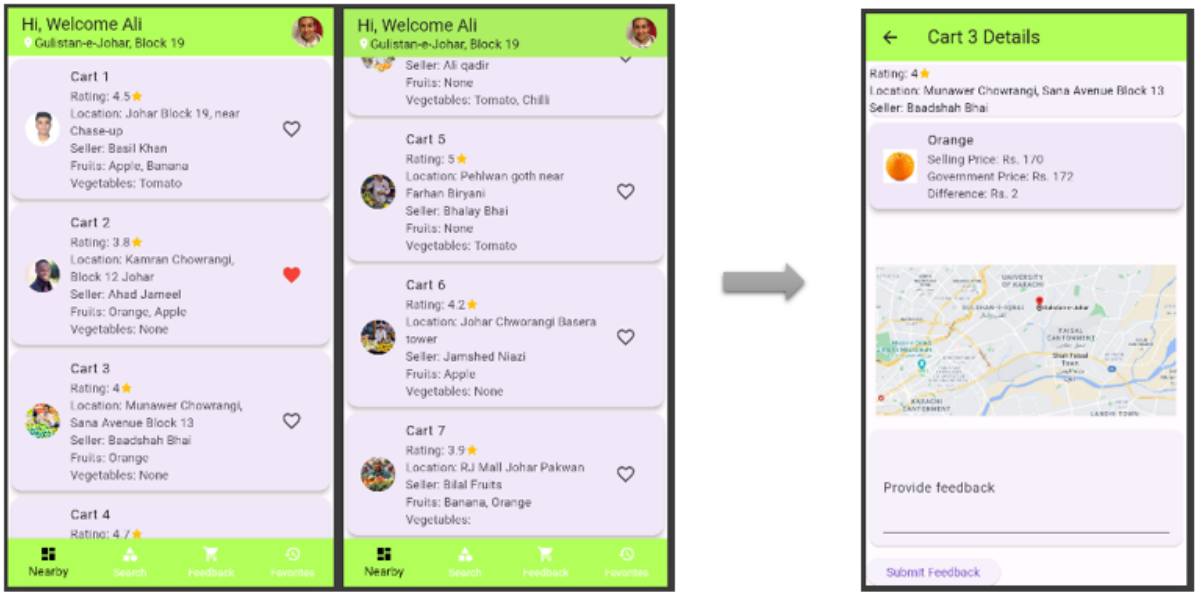

Figure 8 Customer Nearby Cart and Vendor Details Screen

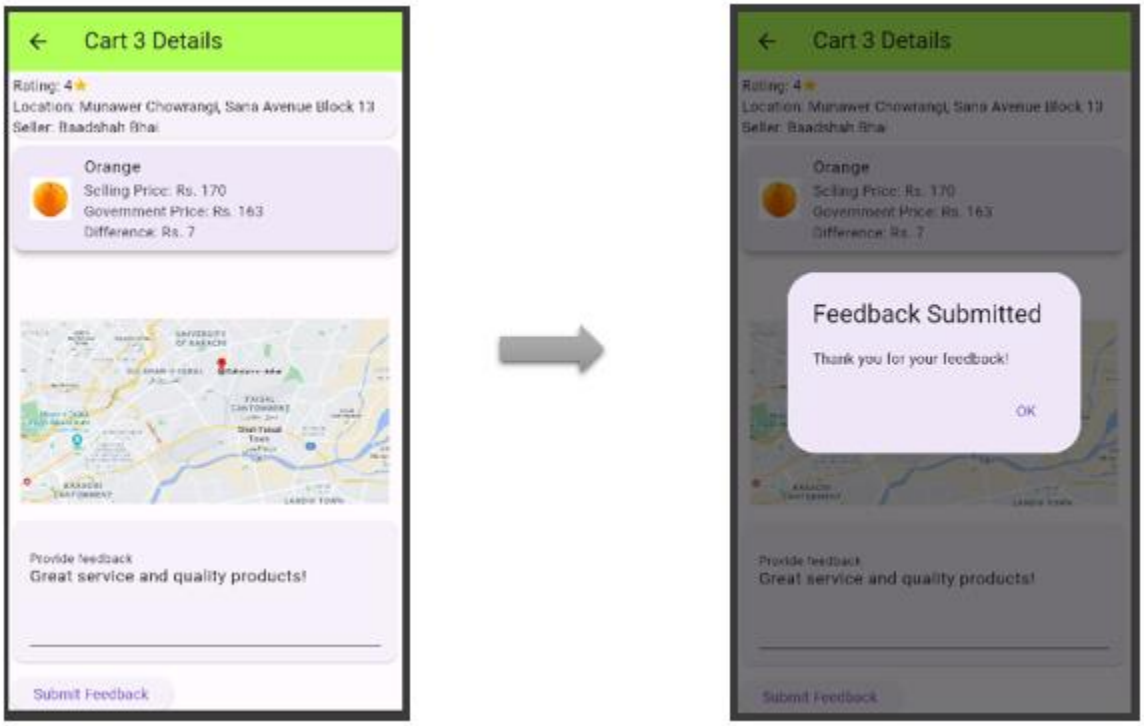

Figure 9 Customer Feedback Screen

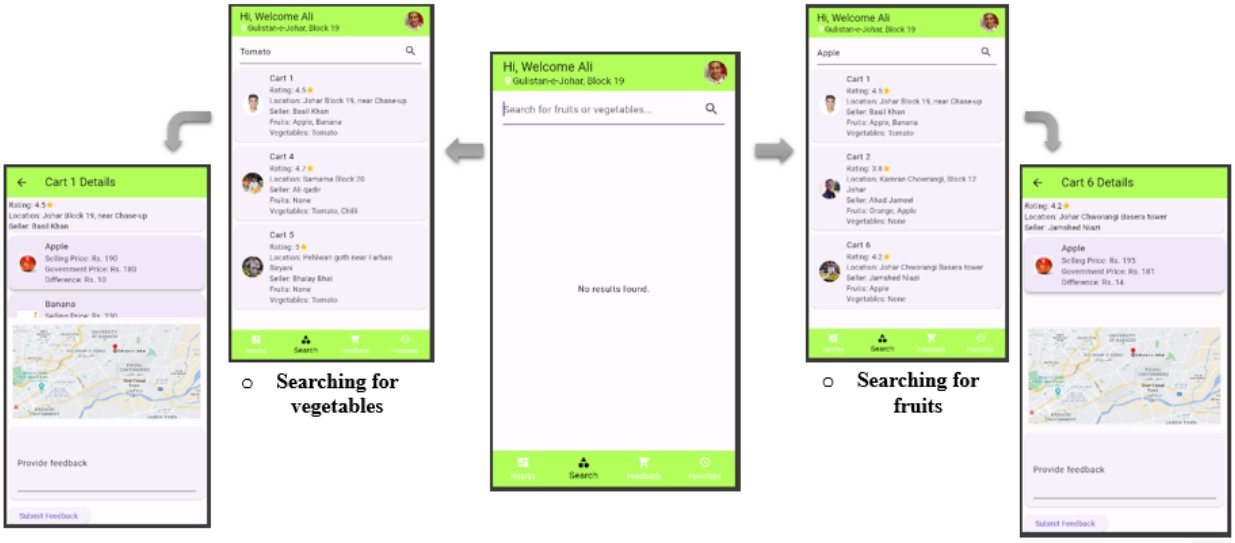

Figure** 10 **Customer Desired Product Search Screen

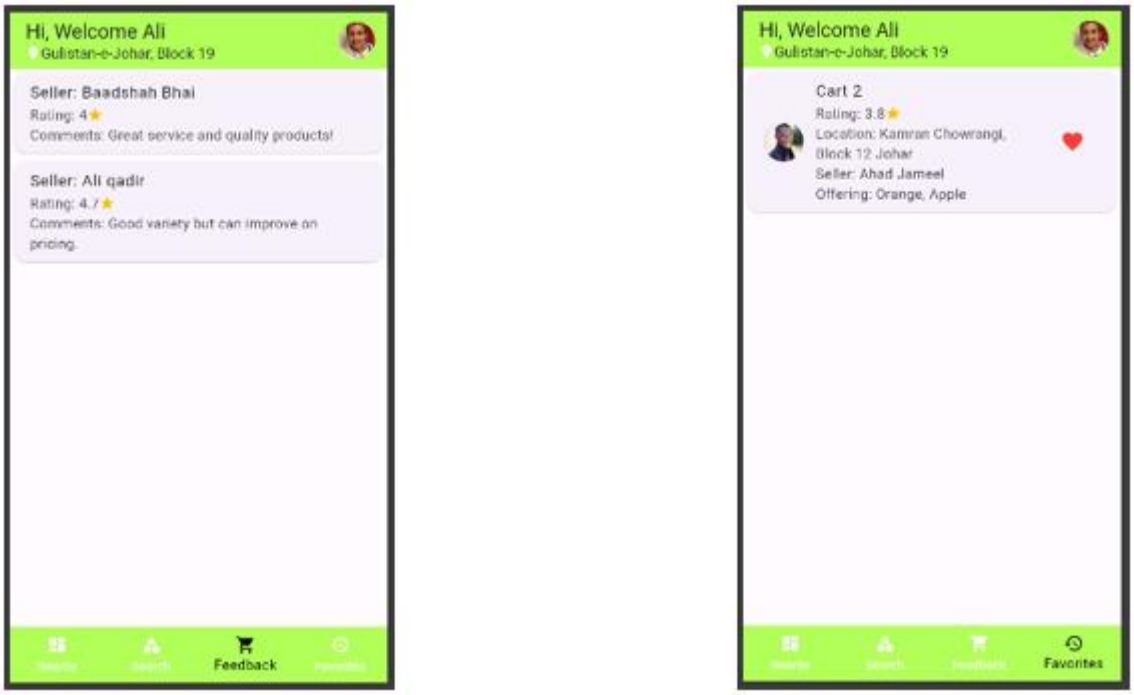

Figure** 11 **Customer Feedback History and Favorites Screen

Deliverable 3

Integration of MobileNet in Application

Research and Selection:

- Conducted a thorough review of deep learning models suitable for image recognition tasks.
- Selected MobileNet for its efficiency and accuracy, aligning with the application's requirements.

Model Integration Planning:

- Outlined a comprehensive plan for integrating MobileNet into the Flutter framework.

Flutter Environment Setup:

- Configured the Flutter development environment, ensuring compatibility with the MobileNet model.
- Installed necessary dependencies and libraries for seamless integration.

Model Adaptation for Flutter:

- Modified and adapted the MobileNet model to suit the requirements of the Flutter application.
- Conducted optimization processes to balance computational efficiency and predictive accuracy.

Integration Implementation:

- Developed and implemented the necessary code for integrating MobileNet into the Flutter application.
- Ensured proper communication between Flutter and the deep learning model.

The integration of MobileNet into our Flutter application has been successfully completed, marking a significant milestone. The steps outlined above demonstrate a systematic and thorough approach to ensure a seamless and efficient integration process.

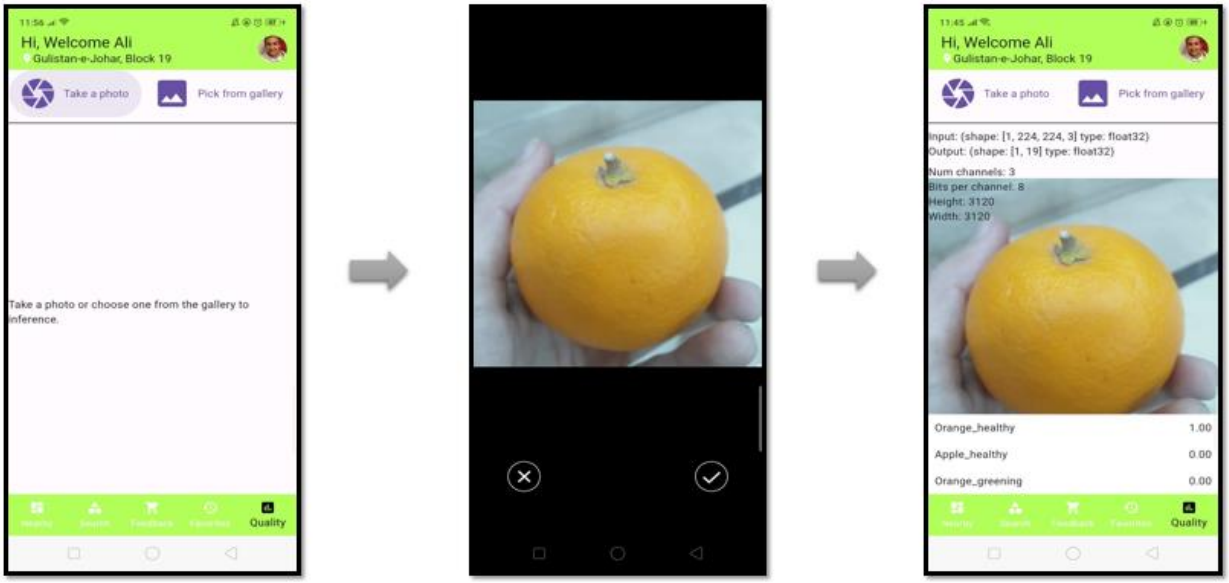

Figure** 12 **Quality Assessment By Taking Picture

Figure** 13 **Quality Assessment By Uploading Picture

Deliverable 4

Implementation of YOLO for improved real-time object detection

Following the training and evaluation of the deep learning classification models, we trained a highly efficient YOLOv8 model to perform real time object detection of the fruits and vegetables. YOLOv8 model was employed to precisely identify and classify the fruits and vegetables based on their quality classes. YOLOv8 is a popular object detection model that is widely used in computer vision applications. Since it is highly precise and computationally efficient, it is appropriate for real-time applications. We specifically chose YOLOv8 because it has an overall improved accuracy and higher speed than its predecessors. YOLOv8 is an open source model designed by ultralytics, hence it is easily customizable.

To train this object detection model, whole data was annotated by precisely creating bounding boxes around each instance. Then the images were scaled to 640x640 pixel size to make it easily usable input for YOLOv8. Keeping the high performance of YOLOv8 in consideration, we kept the number of epochs minimum to keep it least resource intensive, thus at last 20 epochs were set to be optimal.

This trained YOLOv8 model was also tested using real time camera to identify and classify the fruits and vegetables based on their quality. Thus this would be used in a camera mounted on the fruit and vegetables' cart and would be integrated in a mobile application to help fruit vendors and customers to provide a transparent and smooth selling and buying experience.

Table** 2 **Initialization Parameters for Yolov8

Hyper-Parameters	***Value***
Epochs	20

Warm-up bias learning rate	0.1
Batch size	16
Input Image size	640
Weight Decay	0.0005
Momentum	0.937

Bounded Box

A bounding box is a graphical representation of the position of an object in an image. Each image's bounding box includes the ascribes listed below.

1. Dimensions
2. Measurements
3. Class (rotten_apple, bruised_banana, fresh_oranges, etc.).

Figure 14 Bounded Box Example

Test Results

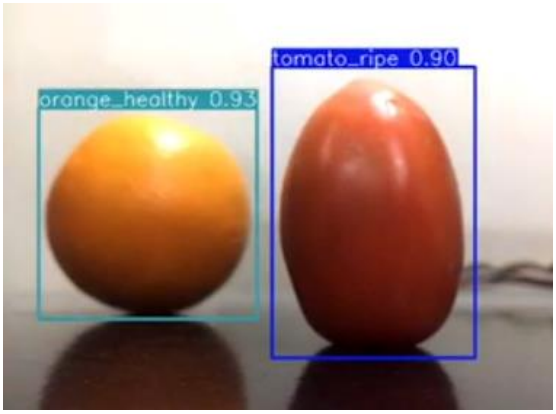

Figure 15 Sample Result 1

Figure** 16 **Sample Result 2

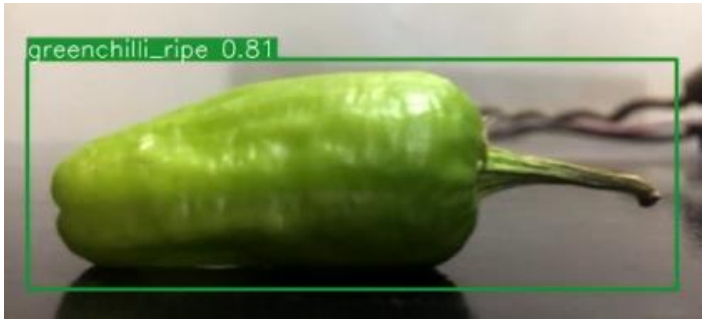

Figure** 17 **Sample Result 3

Updated Timeline

Timeline	Phases	Team Roles
Month 1	Literature Review	Ahad, Jodat
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Month 3	Feature Extraction	Ahad, Basil
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Month 4	Deep Learning Model	Ahad, Jodat, Basil
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 5	Model Testing and Optimization	Jodat, Ahad

Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 6	Mobile App Design	Basil, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 7 (To do)	Mobile App Development	Basil, Ahad
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 7 (To do)	Data Base Integration	Ahad, Basil, Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 7 (To do)	System Integration	Jodat
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 8 (To do)	Evaluation and Testing	Ahad
Discussing the progress with Dr. Muhammad Farrukh Shahid (PI)		
Month 8 (To do)	Documentation and Reporting	Basil, Jodat
Submitting Final Report		

References:

1- IEEE-dataport.org - fruitsgb-top-indian-fruits-quality

2- Kaggle - Fruits and Vegetables dataset

3- FruitNet: Indian Fruits Dataset with quality (Good, Bad & Mixed quality)

4- VegNet: Vegetable Dataset with quality (Unripe, Ripe, Old, Dried and Damaged)

5- Our Dataset

6- Fresh and Rotten Fruits Dataset for Machine-Based Evaluation of Fruit Quality