King Fahad University of Petroleum and Minerals

COE384

Project Management Plan

Project Name:	Smart Fruit Grading System		
Group Number:	1		
Date:	04/ 11/ 2023	**Release:**	Draft
Student 1 Name:	Basil Alashqar	**Signature:**	X
Student 1 ID:	202045700		
Author 2 Name:	Nussair Hroub	**Signature:**	X
Student 2 ID:	201972210		
Author 3 Name:	Raad Al-Utaibi	**Signature:**	X
Student 3 ID:	201972010		
Author 4 Name:	Omar Almutairi	**Signature:**	X
Student 4 ID:	201917610		
Document Number:	T231-COE384-PMP-002		

Revision History

Revision Date	Previous Revision Date	Summary of Changes	Changes Marked
24/10/2023	none	The whole document	Yes
04/11/2023	24/10/2023	The whole document	Yes

Approvals

This document requires the following approvals. A signed copy should be placed in the project files.

Name	Signature	Title	Date of Issue	Version
Dr. Akram		Professor	24/10/2023	001

Distribution

This document has been distributed to:

Name	Title	Date of Issue	Version
Dr. Akram Ahmad	Professor	4/10/2023	002

Contents

1. Executive Summary of Project Charter

In response to challenges in manual fruit grading and sorting within the agricultural industry, the business case document (T231-COE384-BC-002) advocates for the adoption of the "Preferred Solution (Smart Fruit Grading System)." This advanced system integrates computer vision and machine learning to provide precise fruit grading based on parameters like size, ripeness, and quality. It promises substantial efficiency gains, an 85% reduction in labor costs during peak seasons, and long-term cost reduction. However, it entails initial high investment costs and ongoing maintenance expenses. The timescale spans 18 months from planning to long-term benefits. The investment appraisal reveals a significant net present value advantage for the preferred solution. Notably, potential risks encompass regulatory challenges, market adoption, operational downtime, cost overruns, and scope creep, with corresponding mitigation strategies. The project represents a pioneering effort to revolutionize fruit grading and sorting processes. This initiative aims to automate these processes at large factories, addressing the labor-intensive challenges associated with traditional sorting systems. Our project comprises both software and hardware aspects, combining the power of AI and advanced mechanical components to deliver a highly efficient, reliable, and autonomous solution for categorizing fruits into four classes: "inedible," "high," "medium," and "low" quality.

Assumptions for the project revolve around the uniformity of fruit characteristics, consistent lighting, a limited focus on specific fruit varieties, and stable environmental factors during sorting operations, while constraints include cost limitations and safety compliance. The project aims to automate fruit grading and sorting using AI, alleviating labor-intensive processes, with a comprehensive plan encompassing both software and hardware components. On the software side, the project involves data collection, annotation, and deep learning model development, employing an ensemble learning approach. The hardware aspect comprises high-resolution cameras, sensors, mechanical components, and safety mechanisms to efficiently categorize fruits into four classes and sort them. Performance metrics include processing speed and classification accuracy, with deliverables comprising an annotated dataset, a trained deep learning model, and AI-powered sorting machines, forming a robust fruit grading system. The last sections of our PMP document present the WBS and the proposed time management plan.

2. Assumptions/Constraints

<u>Assumptions:</u>

1-Uniform fruit characteristics:

The first assumption is that the fruit being sorted possesses consistent characteristics within each variety. This implies that fruits of the same variety share similar physical attributes, such as size, shape, color, and ripeness. By assuming uniformity, the sorting process can rely on standardized criteria for categorizing and arranging the fruits, streamlining the overall operation.

2-Adequate lighting:

The second assumption is that adequate lighting will be maintained throughout the entire fruit sorting process. Appropriate illumination is crucial to ensure accurate visual inspection and analysis of the fruits.

3-Limited fruit varieties:

The third assumption pertains to the fruit sorting process focusing on a limited range of fruit varieties. By narrowing down the scope to specific fruits or a predetermined set of varieties, the sorting system can be fine-tuned to meet the unique requirements of each fruit type. This approach allows for the development of specialized sorting algorithms, calibration settings, and sorting criteria tailored to the characteristics and attributes of the selected fruits. Consequently, the sorting process becomes more precise, swift, and adaptable to the specific needs of the chosen fruit varieties.

4- Environmental factors:

The last assumption concerns the influence of environmental factors on the fruit sorting process. It is assumed that key environmental parameters, such as temperature and humidity, remain within acceptable ranges during sorting operations.

5- Pre-washed fruits:

The grading system is designed to receive pre-washed fruits and does not include the functionality to wash the fruits.

6- Fruits are given serially:

The number of fruits given at a time is one. The line only handles one fruit at a time

Constraints:

1. Cost Constraint:

   Developing and operating the grading system within a specified budget is crucial to ensure that the project remains financially sustainable and does not exceed the allocated resources. A cost constraint imposes limitations on the financial aspects of the grading system project, requiring careful planning and management of expenses.

2. Safety Constraint:
 The system should ensure the safety of operators and consumers by adhering to radiation safety regulations and guidelines. It should have appropriate shielding and safety features to prevent any potential harm from X-ray exposure.

3. Scope of project

Throughout human history, fruit selection has relied on the sensory evaluation of sight and smell, constituting a fundamental and invaluable yet labor-intensive method. However, this method is subjective and susceptible to errors over time, as some fruits are judged solely on their color or aroma, often leading to inconsistencies in quality assessment. With the emergence of AI in this field, there is an opportunity for technology to replace human judgment and introduce an era of objective and precise fruit quality evaluation, revolutionizing the industry while alleviating labor-intensive processes.

This project fundamentally aims at automating the fruit grading and sorting processes at large factories. Our project will finally alleviate the need for labor-intensive workplaces, mitigating the challenges associated with them.

Our project can be broadly categorized into two major components (software and hardware aspects):

- **Software Aspect:**
  - **Data Collection and Annotation:**

    During the data collection phase, we will undertake a comprehensive training program for a specific workforce within the factory. This training initiative will be overseen by our team of AI experts, who will work closely with AI engineers to outline precise data requisites, including image format specifications and the number of instances per class. Our approach to addressing this challenge involves framing it as a multiclassification task, comprising four distinct categories: "inedible," "high," "medium," and "low." Accordingly, we will gather the necessary data for each of these classes. Subsequently, the collected images will undergo meticulous annotation and will be stored in our database for integration into the deep learning model during the training process. In Figure 1, we show our plan for data collection. As depicted in the figure, we plan to collect 40k samples per fruit type and 10k instances per class.

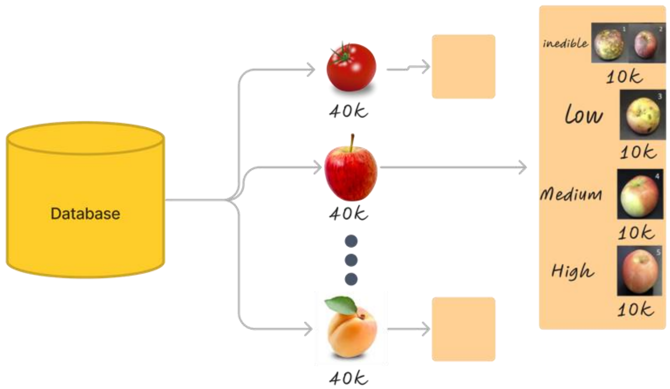


Figure 1. Illustration of the dataset to be used through the training.

- **Deep Learning Model Development and Training**

Numerous deep-learning models are renowned for their remarkable accuracy in handling classification tasks. In our project, we intend to conduct a thorough exploration of various deep-learning models. Our approach will involve experimenting with a diverse range of these models and carefully assessing their performance on our specific classification problem. Following this evaluation, we will identify the top three to five models that consistently exhibit the highest levels of accuracy and effectiveness in categorizing our data. These chosen models will then be integrated into an ensemble learning framework, where their combined predictive capabilities will be harnessed to further enhance the overall performance and reliability of our classification system. Figure 2 better illustrates the idea of the ensemble learning scheme. We propose to apply the simple majority voting technique to combine various models.

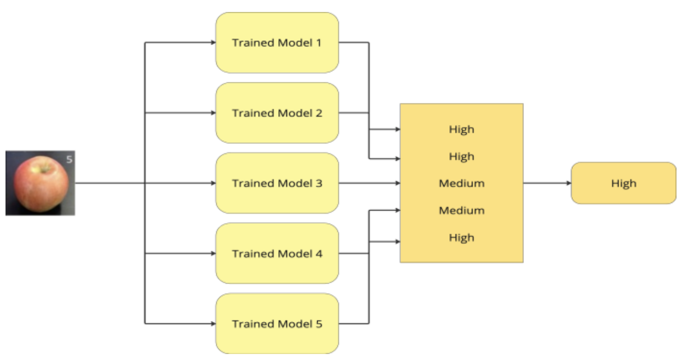


Figure 2. Illustration of the ensemble learning concept

- **Hardware Aspect:**

Designing a smart fruit grading system involves a multi-step process, which relies on various hardware components to categorize fruits seamlessly and efficiently into four classes (inedible, high, medium, and low quality) and sort them into respective boxes. The process begins with high-resolution cameras capturing images of the fruits as they move along a conveyor belt. These images are then processed by a powerful CPU or GPU, possibly with a dedicated machine learning accelerator, where AI algorithms analyze factors like color, size, ripeness, and defects to classify each fruit into its appropriate category. This critical decision-making phase is backed by memory and storage components to hold images, sensor data, and model parameters. Once classified, the fruits are routed using mechanical arms and conveyor systems to their respective boxes, guided by AI-controlled actuators. Additionally, weight scales are employed to measure and further refine the categorization based on weight. Throughout the process, the system ensures consistent environmental conditions with environmental sensors while safety mechanisms protect both operators and the machinery. An HMI allows for user-friendly control, while connectivity options enable remote monitoring and data sharing.

Key hardware components required for the smart fruit grading system include high-resolution cameras, color and spectral sensors, weight scales, powerful CPUs/GPUs, machine learning accelerators, microcontrollers or FPGAs, memory, storage, connectivity options like Ethernet and Wi-Fi, conveyor belts, mechanical arms, pneumatic systems, environmental control sensors, power supply, safety systems, casing, cooling systems, data storage and backup, AI hardware accelerators, quality assurance devices, network infrastructure, backup power supply, maintenance tools, and data storage and analysis servers. This comprehensive hardware setup ensures the system's smooth operation, accurate fruit classification, and efficient sorting while allowing for remote monitoring, data analysis, and long-term data storage. The combination of these components forms a robust and intelligent fruit grading system that can significantly enhance the efficiency and precision of fruit processing and distribution operations.

- **Top-view of product of project:**

  The physical representation of the project is illustrated in Figure 2, showcasing the top view of the product. The project involves the integration of an AI-trained module, which will be installed within a microcontroller. A series of cameras will be deployed to capture images of the fruit, which will then be transmitted to the microcontroller for analysis. Subsequently, the microcontroller will execute the AI-trained module to determine the fruit's quality grade. Following this assessment, the microcontroller will take control of a gate, directing the fruit to one of four designated lines labeled as 'High,' 'Medium,' 'Low,' and 'Inedible. The shown raspberry pi in figure 2 is just an example and not mandatory to select for the project.

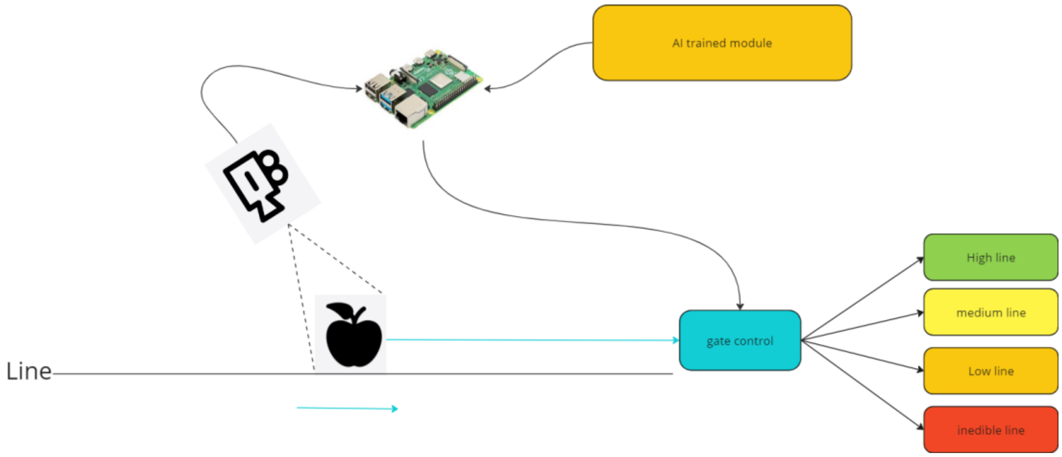


Figure 2 3 top-view of the product of project

Deliverables:

1. Annotated Dataset.
2. Trained Ensemble Deep Learning Model.
3. AI Empowered Fruit Grading and Sorting Machines.

Measuring Criteria:

1. Speed of Processing
2. Correctness of classification

Out of the scope:

1. The project's sole objective is to replace human involvement in fruit grading. Activities such as fruit cleaning and packaging are explicitly excluded from the project scope.

4. Work Breakdown Structure

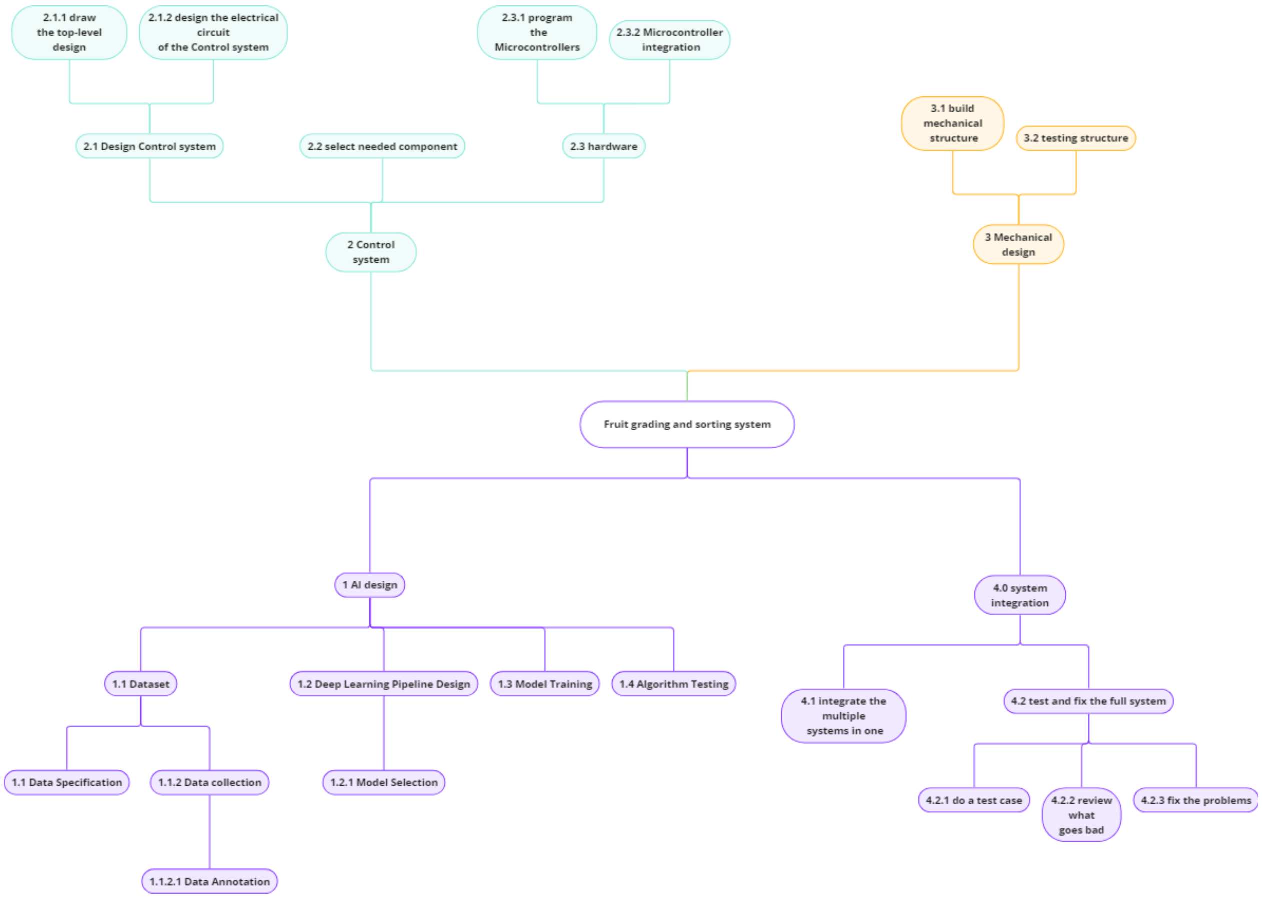


Figure 4 work Breakdown Structure

5. Change Control Management

No changes are permitted on this document.

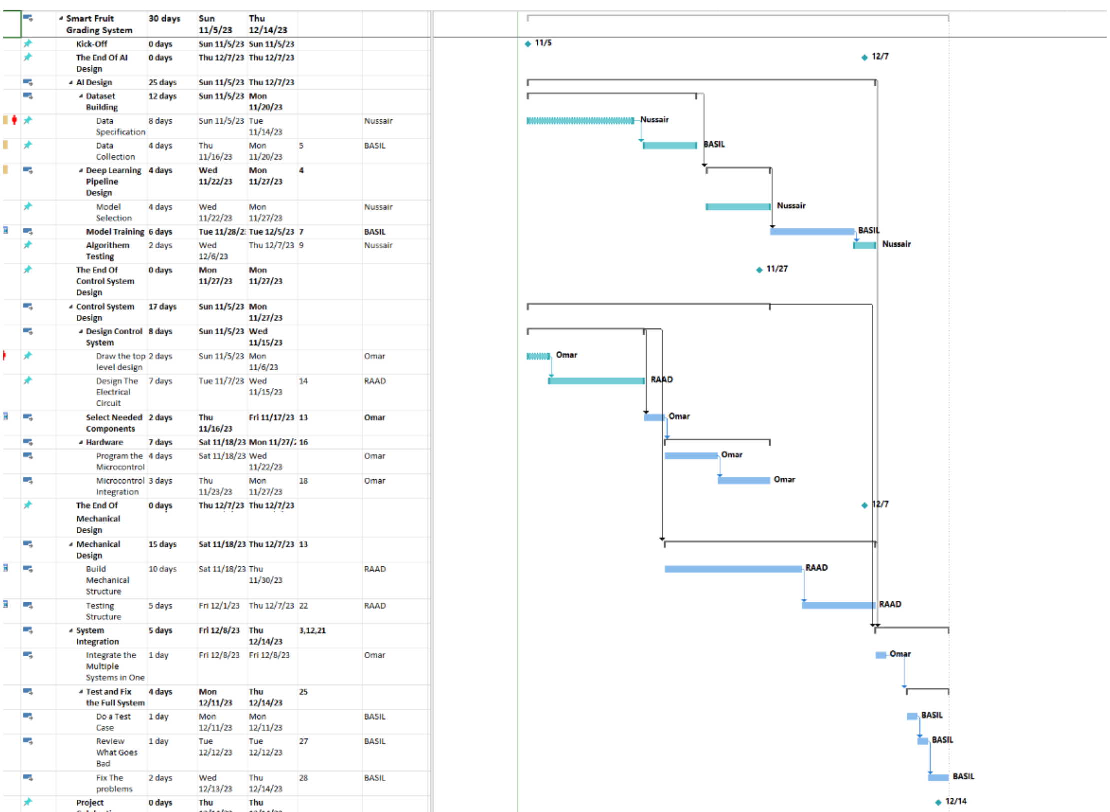
6. Schedule/Time Management

6.1. Milestones

The table below lists the milestones for this project, along with their estimated completion timeframe.

Milestones	Estimated Completion Timeframe
Kick-off	**0**
AI design	**25 days**
Mechanical structure & control design	**25 days**
System Integration	**5 days**
Closing	**0**

6.2. Project Schedule



Smart Fruit Grading System	30 days	Sun 11/5/23	Thu 12/14/23		
Kick-Off	0 days	Sun 11/5/23	Sun 11/5/23		
The End Of AI Design	0 days	Thu 12/7/23	Thu 12/7/23		
AI Design	25 days	Sun 11/5/23	Thu 12/7/23		
Dataset Building	12 days	Sun 11/5/23	Mon 11/20/23		
Data Specification	8 days	Sun 11/5/23	Tue 11/14/23		Nussair
Data Collection	4 days	Thu 11/16/23	Mon 11/20/23	5	BASIL
Deep Learning Pipeline Design	4 days	Wed 11/22/23	Mon 11/27/23	4	
Model Selection	4 days	Wed 11/22/23	Mon 11/27/23		Nussair
Model Training	6 days	Tue 11/28/2:	Tue 12/5/23	7	BASIL
Algorithem Testing	2 days	Wed 12/6/23	Thu 12/7/23	9	Nussair
The End Of Control System Design	0 days	Mon 11/27/23	Mon 11/27/23		
Control System Design	17 days	Sun 11/5/23	Mon 11/27/23		
Design Control System	8 days	Sun 11/5/23	Wed 11/15/23		
Draw the top level design	2 days	Sun 11/5/23	Mon 11/6/23		Omar
Design The Electrical Circuit	7 days	Tue 11/7/23	Wed 11/15/23	14	RAAD
Select Needed Components	2 days	Thu 11/16/23	Fri 11/17/23	13	Omar
Hardware	7 days	Sat 11/18/23	Mon 11/27/:	16	
Program the Microcontrol	4 days	Sat 11/18/23	Wed 11/22/23		Omar
Microcontrol Integration	3 days	Thu 11/23/23	Mon 11/27/23	18	Omar
The End Of Mechanical Design	0 days	Thu 12/7/23	Thu 12/7/23		
Mechanical Design	15 days	Sat 11/18/23	Thu 12/7/23	13	
Build Mechanical Structure	10 days	Sat 11/18/23	Thu 11/30/23		RAAD
Testing Structure	5 days	Fri 12/1/23	Thu 12/7/23	22	RAAD
System Integration	5 days	Fri 12/8/23	Thu 12/14/23	3,12,21	
Integrate the Multiple Systems in One	1 day	Fri 12/8/23	Fri 12/8/23		Omar
Test and Fix the Full System	4 days	Mon 12/11/23	Thu 12/14/23	25	
Do a Test Case	1 day	Mon 12/11/23	Mon 12/11/23		BASIL
Review What Goes Bad	1 day	Tue 12/12/23	Tue 12/12/23	27	BASIL
Fix The problems	2 days	Wed 12/13/23	Thu 12/14/23	28	BASIL
Project Celebration	0 days	Thu 12/14/23	Thu 12/14/23		