G52GRP Interim Group Report

Semi-automated Sorting System for Germinated Oil Palm Seeds

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Group ID: 7b

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Abstract

In the past 50 years, the increasing demand for oil palm seeds worldwide has subsequently increase the palm oil production industry. [1] This project focuses on producing a system that could classify the quality of each palm oil seed as a good or bad seed, through the detection and analysis of the images of every tray of seeds that are being captured and collected by the camera. The system is designed to be semi-automated, which means that human workers are required as part of the project for the operation to be carried out, while the system handles the computing and processing with the implementations of several technologies including machine learning and image processing. The purpose of developing such system in the oil palm industry is to pursue the importance of being more work-efficient and to automate manual work. This project mainly focuses on developing a system to replace the decision making in the existing seed classifying system to improve reliability and accuracy. This system aims to prove the concept of integrating machine learning and image processing into the oil palm production industry and reduce labour cost while increasing its efficiency.

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1. Introduction

1.1 Purpose

The objective of this project is to create a system that automatically captures the images of the trays of seeds on the conveyor belt, identifies the seeds in the images with image processing, predicts the quality of the seeds with AI and display the results through an output device, namely a projector. Manuel labour will be required to remove the bad seeds from the tray. In the existing quality control system, some trays are sampled every batch for quality checking, however this system aims to check through every single tray with added reliability, improved efficiency and reduced labour cost.

1.2 Client: Advanced Agriecological Research Sdn. Bhd (AAR)

Advanced Agriecological Research Sdn. Bhd. is a wholly owned subsidiary of Applied Agricultural Resources Sdn. Bhd. AAR has emerged as a leading tropical plantation crop research centre since its establishment in July 1986. AAR has more than 400,000 hectares of oil palm estates which belonging to their commercial clients and Principals in Colombia, Liberia, Indonesia, and Malaysia. They also have more than 65 research executives. [2] In line with their slogan “Tomorrow’s oil palm today”, [3] our client, ARR’s goal is to make a semi-automated sorting system for germinated oil palm seeds as a form of quality control to ensure the quality of the oil palm seeds before sending them out to their customers. This system will reduce the manpower for sorting the germinated oil palm seed manually and make the work more efficient.

1.3 Project Scope and Deliverables

Our project involves the development of a semi-automated germinated oil palm seeds quality control system while making use of Image Processing, Machine Learning, Human Computer Interaction, and Internet of Things to provide our client with a solution to semi-automate checking the quality of the seeds. Upon the completion of our project, our system is expected to autonomously take images of the tray of seeds in successions, reliably detect the seeds in the image, classify the quality of seeds on the tray with coloured bounding boxes, and a projector to overlay the tray of seeds with the resulting bounding boxes. The entire process of the system shall be controllable and interactable by the user via physical buttons and a GUI. This includes the functionalities of starting, pausing, terminating the program as well and accessing the database. The system is also expected to be implemented on the Raspberry Pi.

1.4 Background Research

1.4.1 Existing Solutions

The AAR company since its establishment has been using the traditional method of sorting oil palm seeds using workers as part of their quality control process. The workers will be sorting and identifying these seeds based on their training and experience in sighting the physical condition of the seeds.

Workers need to be added to increase the production of sorted seeds and these workers will have to be trained to ensure the quality of these seeds are monitored and maintained. The disadvantages for such a manual process would be affected by human behaviour and social interactions both at home and at work. Therefore, the welfare and health of the workers are equally important for producing good yield of quality seeds.

Trained and experienced workers can easily differentiate good and bad seeds based on the condition of the seedlings. The speed of sorting will be limited by the number of workers and by the experience of the workers. [4]

1.4.2 Literature Review

This section will discuss the features to be implemented in our application.

Vision Sensors

Individual inspection of seeds by ordinary workers is a very tedious and time-consuming process, and the performance of personnel declines with time over long working hours, which leads to human error and degrades the quality of inspections. Considering that we'll be using image processing technologies in our system, Vision Sensors will come in handy as IP programs require them to operate. Vision Sensors have built-in light rings that could illuminate the target object, target surface and background to be captured, so that shadows would not be visible and lead Machine Learning (ML) to false detection of seed quality Reducing shadows in images could also be solved through a backlighting function which could help to avoid false detection when capturing the seeds images. There are many lighting options such as Ultraviolet and Infrared in Vision Sensors, as well as different lightings that could enhance the performance of the system, as under different lightings depending on different situations could allow the images to be displayed more clearly and detailed to our naked eye. By having those lightings, even the smallest details of the seeds could be captured, and which could increase the accuracy of results being produced in our project. Other than that, the lenses of Vision Sensors are changeable, so that images could be captured in a wider range of angles. As Vision Sensors supports 3D imaging that could capture 3D objects accurately, the accuracy of the seed quality classification will improve significantly if provided with more camera angles of the seeds. [5] [6] Inspection System could also be carried out with the help of Match Sensors, which is also part of the Vision Sensors. Match Sensors are useful for our project when it comes to checking if the positions of every seed are correctly placed in the trays, and it could also be utilized to verify the labels and barcodes tagged on every tray.

Machine Learning-based Image Processing and Computer Vision for seed measurement

In our project, a combination of both Machine Learning and Computer Vision with imaging techniques aimed towards extracting phenotypic traits of seeds from images will be used for seed quality classification. Machine Learning (ML) requires a large amount of data or past information to produce a high accuracy prediction and result. Image Processing (IP) which is one of the Computer Vision (CV) techniques, takes part in understanding and recognising the patterns of the input images of every captured seed. [7] The collected data will be processed and analysed through IP, then ML algorithms will utilise the collected image data to start its prediction on the quality of every seeds through one of the ML techniques implemented, and which in this case is the Unsupervised Learning technique, as this technique is the method that we require for a sorting system, by grouping and interpreting data based on unlabelled input data. To dispatch high quality seeds, traditional oil palm seed production is laborious and prone to human error. The techniques to extract phenotypic traits of seeds from images automatically are gaining great interest in the seed industry as an alternative method for seed quality assessment. In addition, in traditional methods, extracted morphological traits which are hand-crafted may not have enough information to understand the features of seed. A recent study stated that germinated oil palm seed images are arranged and captured so that it can be detected easily whereas both detecting and classifying individual seeds are challenging. [8]

Convolutional Neural Networks (CNNs) - for training model

In recent studies, Convolutional Neural Networks (CNNs) have demonstrated superior performance over traditional methods in classifying Crambe seed quality based on X-ray images, but they may not have important information to determine seed quality in X-ray images. The advantage of using CNNs is to let a model learn the features that are discriminant for a classification task but with large amounts of labelled data. [9]

Besides that, Alzubaidi, L et.al (2021) studies have also proven that CNN is the most famous and commonly employed algorithm as it can automatically identifies the relevant features without any human supervision. [10]

By implementing CNNs, our models will be able to learn the features that are discriminant for a classification task given a larger amount of labelled data to increase its accuracy in classifying seed quality. The Deep Learning Convolutional Neural Networks (DCNN) algorithm used in the provided algorithms will also improve the image detection model by optimizing the classification of bounding boxes [11] based on each resulting image produced.

2. Project

2.1 Project Description

The proposed project aims to develop a proof-of-concept semi-automated sorting system to detect individual germinated oil palm seed(s) in an optical image that is captured in a controlled environment, and to label the individual seeds based on their quality being good or bad. The focus of the project is to construct a small-scale hardware platform based on an existing sorting kit that can take images of germinated oil palm seed(s), process the images and classify the seeds on an edge device, and sort the seed(s) manually based on the outcome of the classification. The arrangement of the seeds will be done manually before images are taken and each tray can hold up to 100 seeds in a 10 by 10 grid. The edge device will be connected to a projector to project an overlay over the tray of seeds to indicate positions of the bad seeds on the tray. The worker will replace the bad seed with good seed manually based on the overlay from the edge device. The algorithm for the image processing will be provided by Advanced Agriecological Research Sdn. Bhd. A barcode system will also be implemented to authenticate and keep track of the sorted and quality-controlled trays of seed.

2.2 Underlying Assumptions

To carry out the operations of our system, it must be done indoors so that it will not be affected by pests or weather issues. There is also a need for manual workers to place and replace the seeds on the tray during the process. During the arrangement of seeds onto the tray, the seeds must be placed in a way where their shoots and roots are visible to the camera taken from above. This allows the algorithm to process the image taken accurately and precisely without complications. An edge device such as the Raspberry Pi will be used to run the image processing and serves as a hub for linking the other devices, therefore a stable electrical supply is needed to avoid any complications during the operation.

2.3 Operating Environment

In this globalization and modernization era, two popular operating systems are Microsoft Windows and Apple's macOS. According to Statcounter GlobalStats, Windows and macOS have 79.38% and 11.74% market share correspondingly in Malaysia. [12] Therefore, in order to get the most coverage of prospective clients, the system GUI will be developed to work on both top used platforms. The application will be available for the devices running on Windows 10 or later and macOS Catalina or later. It is because there are 85.71% of macOS users running macOS Catalina or later [13] and 80.87% of Windows users running Windows 10 or later [14] which allow the application to be available to most of the operating systems used in Malaysia.

On the other hand, the application will also be runnable on Rasphian operating systems. The raspberry pie will act as the edge device in the model to perform image processing to distinguish the quality of each tray or batch of seeds.

2.4 Design Implementation Constraints

The design of the project will be implemented in several different stages as this is a large project that incorporates different technologies. The client did not give any suggestions about the design for User Interface. There was also no suggestion about the operating environment by the client. They clarified that the user interface should be more interactive, clear, and easy to understand and operate so the workers can easily understand the result of the sorting system. There was no restriction given by the supervisor and the client. The clients expected there to be a barcode system for the seed tray so that they can easily track the seeds that are sorted. Cloud computing is not selected for image processing due to a lack of internet infrastructure. Therefore, edge devices such as Raspberry pie are chosen to host the server for image processing.

2.5 Target Audience

Currently, the system is developed to only be used by our client, Advanced Agriecological Research Sdn. Bhd (AAR) based on the specification provided by them. Our client, ARR, will be using this system as a form of quality control to ensure the quality of the oil palm seeds before sending them out to their customers. This system of using image processing for quality control may be used or further developed for other companies that require a similar system. This system may be integrated to other systems in the industry which are up to the client themselves.

3. Requirement specification

3.1 Functional requirement

1. IO Device
    - The system shall make use of a camera for data input and sensors for motion detection.
    - The system shall make use of a projector to output the results.
2. Image Capture
    - The image captured must be of high resolution (1080p), well-lit and high in clarity.
3. Accessing Image storage
    - The user shall be able to access the images taken by the camera as well as the resulting images produced by our system.
4. Database System
    - The database system shall be able to input the data provided by the image classification algorithm.
    - The database system shall be able to store the unique tray ID, batch ID, filename of the classified tray of seeds and the data regarding the quality of the seeds.
    - The user shall be able to search, select, update, and delete the data stored in the database.
5. Local Image storage
    - The images of the seed trays taken by the camera and the resulting images from the seed classification shall be stored in an expandable local storage system.
6. Image Processing
    - The image processing algorithm shall be able to detect the location and boundary of the seeds in each tray accurately.
7. Image Classification
    - The system shall be able to accurately classify good, bad and invalid seeds in a given tray within a very short time frame.
8. Human Computer Interaction
    - The user shall be able to interact with the system through a dedicated GUI using a mouse and keyboard.

- The user shall be able to stop the system forcefully through a physical button.

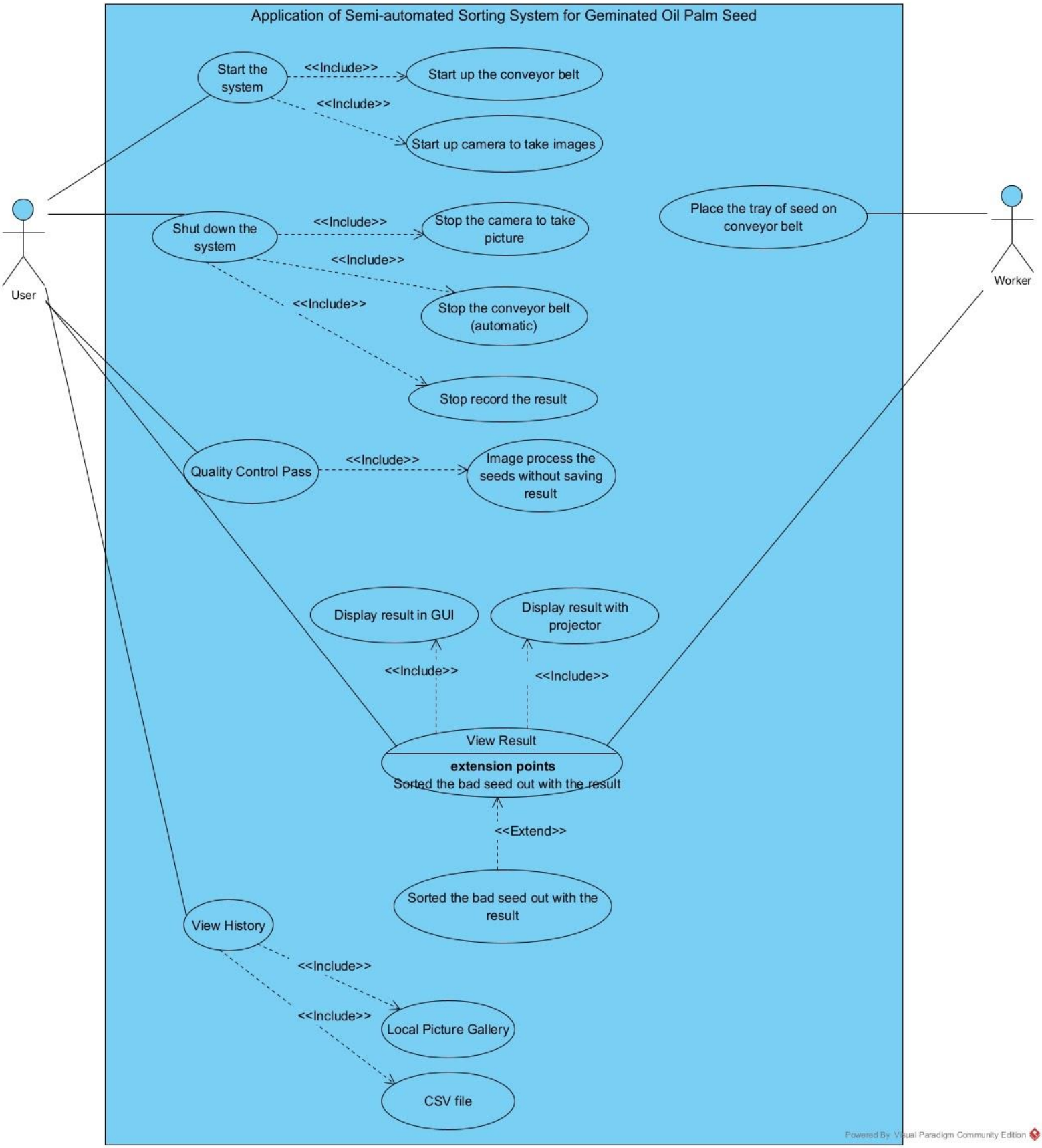
9. Machine learning
    - The machine learning algorithm shall be able to produce reliable prediction results.
    - The machine learning algorithm shall be able to improve itself over time.

3.2 Non-functional requirement

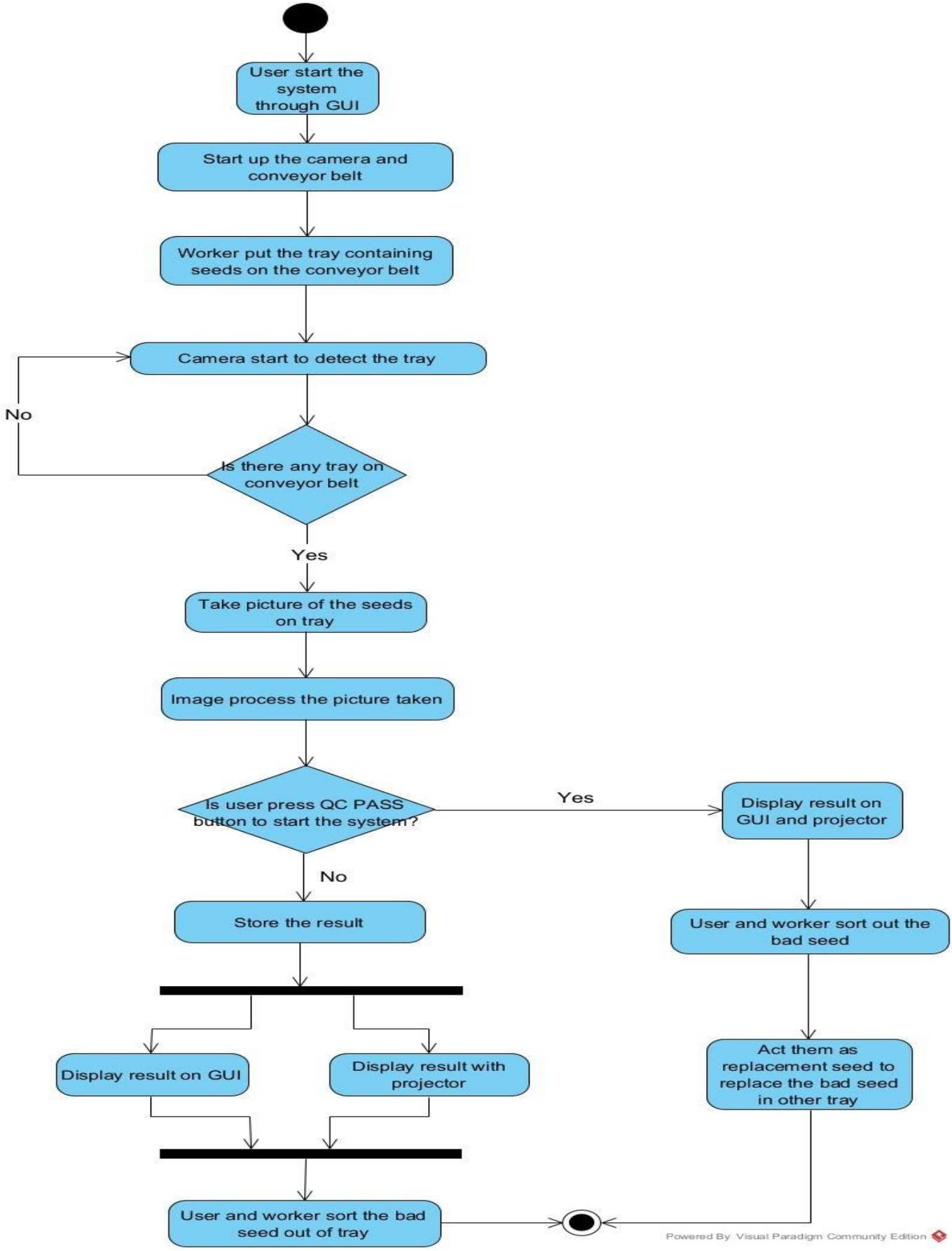
1. Performance requirement
    - The software system shall be efficient to run on an edge device.
    - The software system shall be fast to produce results instantaneously
2. Programming language requirement
    - Python shall be used for the GUI design implementation, seed detection and classification algorithms.
3. Edge device requirement
    - The system shall be running on a Raspberry Pi device and its dedicated operating system (NOOBS OS).
4. Error handling
    - The system shall be able to provide error messages for troubleshooting.
    - The user shall be able to terminate and resume the system while fixing the error.
5. Data type requirement
    - Input images must be in .jpg file format and a fixed resolution of 1080 x 1920p.

3.3 System Design

3.3.1 Use Case Diagram



3.3.2 Activity Diagram



3.4 Prototype

Prototyping is an experimental process of developing software applications where the teams implement their ideas into tangible forms from paper to digital. Building prototypes of varying degrees of fidelity to capture design concepts and test on users. With the prototype, we can refine and validate the design of the application so that we can make sure the product is on the right design.

3.4.1 Low Fidelity

A low-fidelity prototype was created to represent the concept, basic structure, and functions of our project. It allowed us to obtain quick feedback on our concepts and ideas, along with quickly communicating the aforementioned to the supervisor and clients.

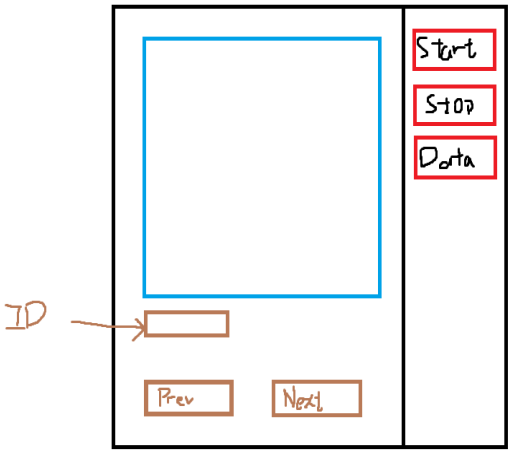


Figure 1: Low fidelity: of GUI

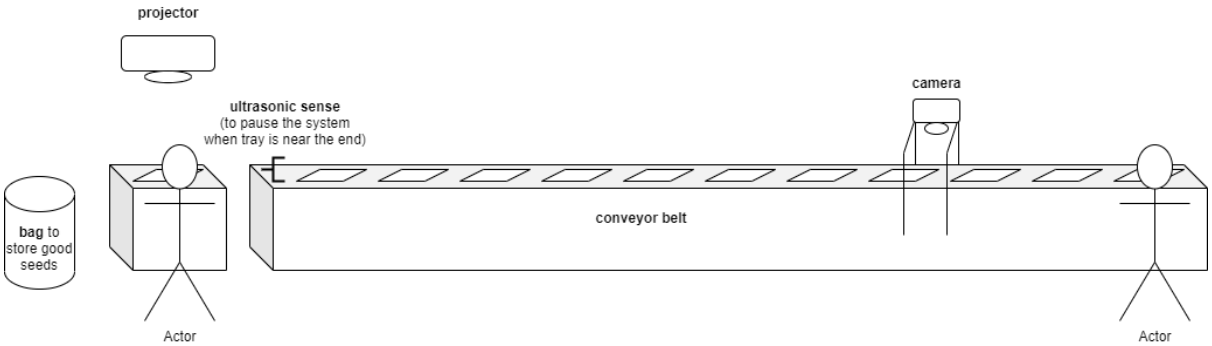


Figure 2: Low fidelity: of whole system

3.4.2 Medium Fidelity

A medium-fidelity prototype was built upon user scenarios and use cases. Through these prototypes, the view of our project can be more easily presented. A correct content description is emphasized. For every action step, a basic visual design is created. The medium fidelity prototype is suited for the validation of the interaction concept with the client.

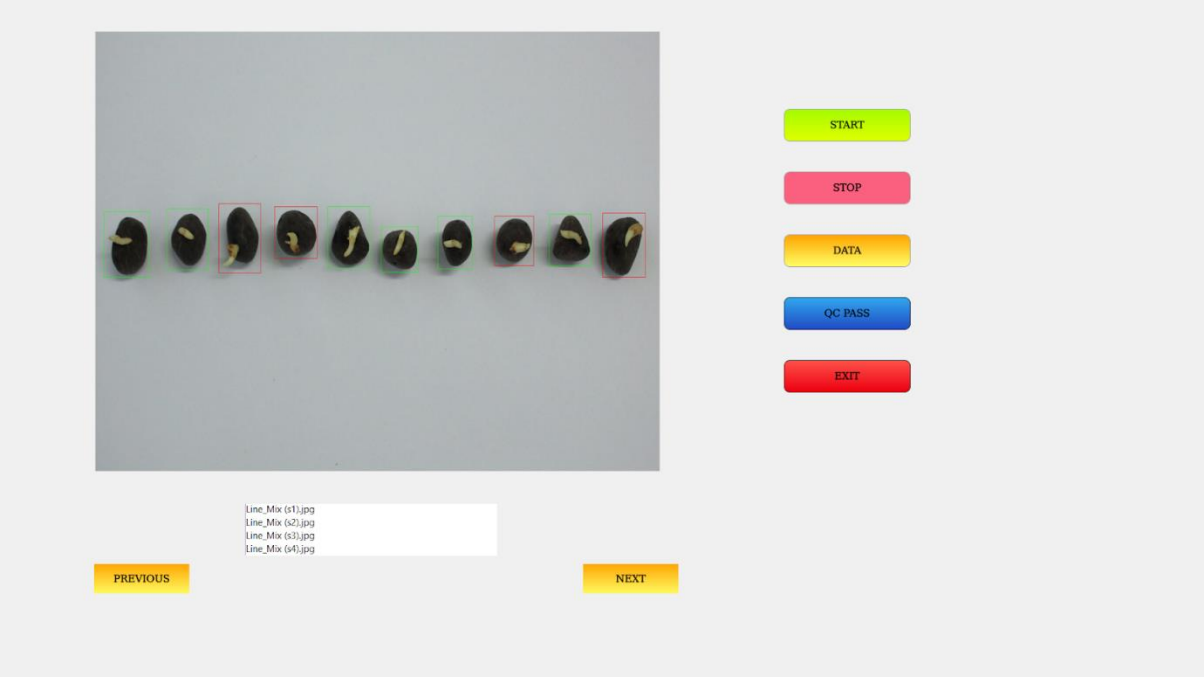


Figure 3: Medium fidelity: of GUI

4. Implementation

4.1 Key Implementation Decisions

Since our project involved image processing technique and the algorithm of image processing given by (our supervisor, Dr Iman) is written in python. Our main concern with developing the app is time constraints and lack of experience since most of the group members are not familiar with Java. Therefore, we decided to use Tkinter for GUI as it is easier to use and more popular.

4.1.1 Programming Languages and Framework

Python

Python is an object-oriented language and high-level programming language with dynamic semantics. It combined dynamic typing and binding with high-level built-in data structures. Python contains a lot of features that can be used for a broad variety of complex application development.

Python is simple and syntax is easy to learn that emphasizes readability of code, therefore cost of maintenance can be reduced. With the support of modules and packages, we are encouraged to program modularity and code reuse.

4.1.2 Collaborative Software

Microsoft Teams

Microsoft Teams is a hub for team collaboration to integrate people so that our team can be more engaged and effective. It is a communication platform developed by Microsoft which offers a workspace to chat and videoconferencing and integration. Microsoft teams is a platform to have meetings with clients and within the team.

WhatsApp

A communication platform that allows people to form group chats and have discussions. The software provides a suitable environment for suggesting ideas

and sending documents. It also has the functionality of starring (or pinning), which is convenient for users to remember important notes and meetings to attend.

Jira

Jira Software is a work management tool for all kinds of use cases. It is used for every team member to plan, track, and release a good project. It is used to distribute tasks across your project team and let all members know the up-to-date information.

Google Docs

Google Docs is useful to collaboratively edit documents together as a team. By having this usage, the team does not have to compile every section of the report into one full report in the end, which helps our team to finalise our report in a shorter time. With using Google Docs can reduced the problems for combining the group work because every team member could read what the others are writing, and make changes to their own sections, or help the others if necessary.

GitHub

GitHub is a code hosting platform for version control and collaboration. It lets our team work together on projects from anywhere. By creating branches, we can keep and share the team's code.

4.1.3 Additional Tools

PyCharm

PyCharm is the IDE (Integrated Development Environment) used for GUI design implementations and the algorithms, as the project is being programmed in Python programming language.

PyTorch

PyTorch is an open-source machine learning framework that accelerates the path from research prototyping to production deployment. It is an optimized tensor library primarily used for Deep Learning applications using GPUs and CPUs. It is an open-source machine learning library for Python,

TensorFlow

TensorFlow is an open-source library to develop and train machine learning models. It is an end-to-end open-source platform for machine learning. It let researchers work in machine learning and developers can build and deploy ML powered applications easily with comprehensive, flexible ecosystem of tools, libraries, and community resources

Tkinter

Tkinter is Python's standard GUI (Graphical User Interface) package. Even Though Tkinter is not the only GuiProgramming toolkit for Python, however it is the most used one. Besides, the Tkinter package is the standard Python interface which is available on most platforms. There are a lot of GUI frameworks in Python, but Tkinter is the only framework that can be built into the Python standard library.

4.2 Frontend Implementation

4.2.1 Main Functionality Screen

This section covers the design aspects of the "Output" screen with the functionable buttons, and the list box of the result pictures as shown in figure 1. This screen allows the user to press the buttons to start or stop the semi-automated sorting process. The list box shows the filename of result pictures that were saved previously which allows users to see all the saved pictures whenever they want. Next and previous buttons are for showing the saved results. Data button is to show the csv file which will be explained in the next section.

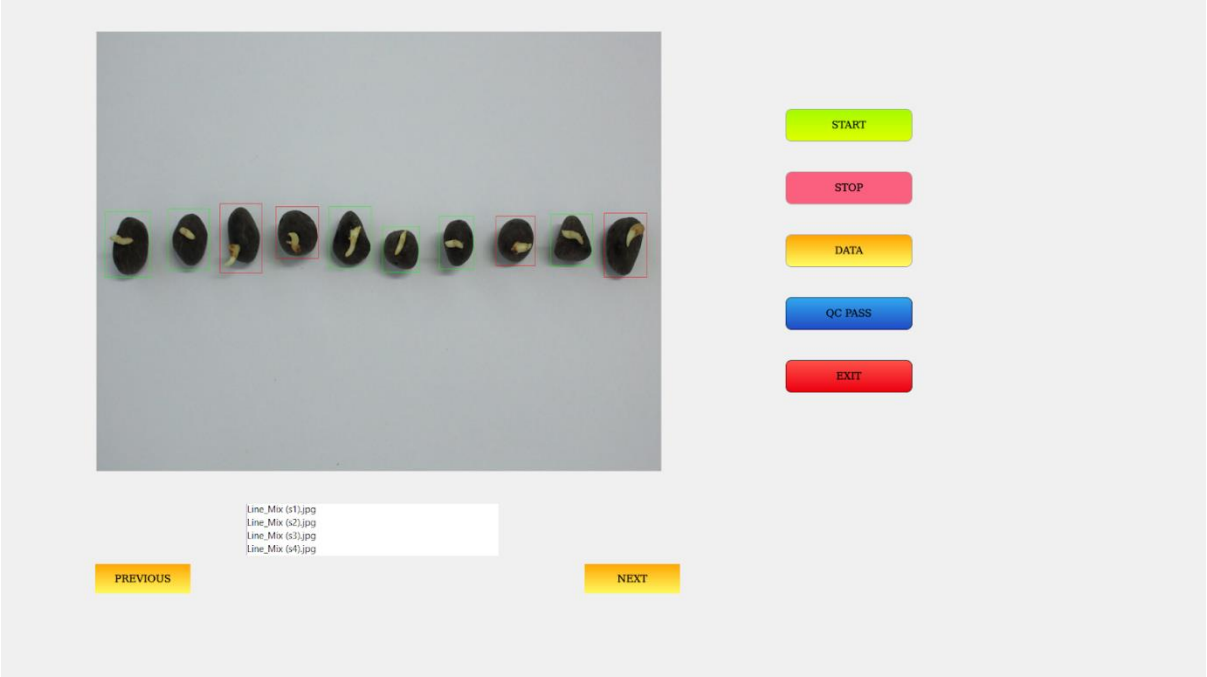


Figure 4: Main screen

4.2.2 Read CSV Data Screen

This section covers the design aspects of the “Data” screen which is a pop-up window after clicking the “Data” button. This pop-up window allows the user to read the .csv file that user has set in advance. User will be only able to read the data of the .csv file (e.g: ID, filename, batch number and date).

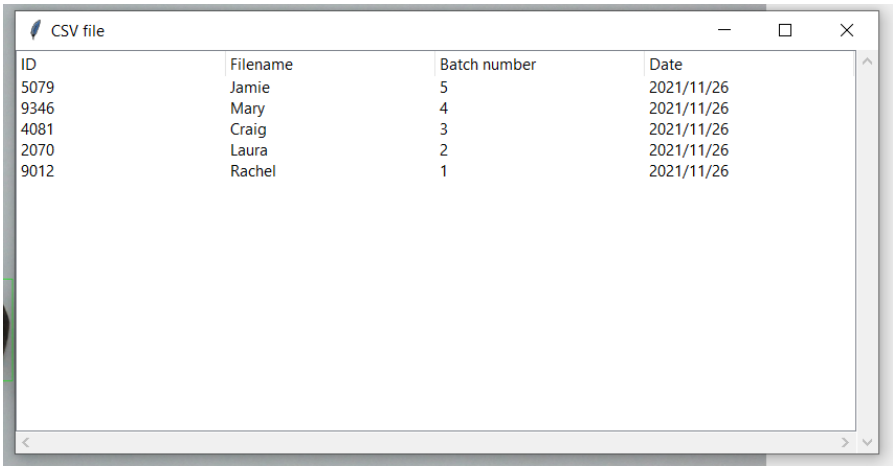


Figure 5: Read CSV Data screen

4.3 Backend Implementation

4.3.1 Image Processing Algorithm

For our seed detection, we will be using two different types of image processing algorithms: seed pre-process and seed segmentation. The former is an algorithm to pre-process the image and create a seed mask while the latter is to detect the positions of the seed in the image.

Seed Pre-process

The seed pre-processing algorithm will receive the input of the seed tray images in .jpg format from the input folder and processes the image with a trained model to generate a mask image of the seeds to be sent to the seed detection algorithm for further processing.

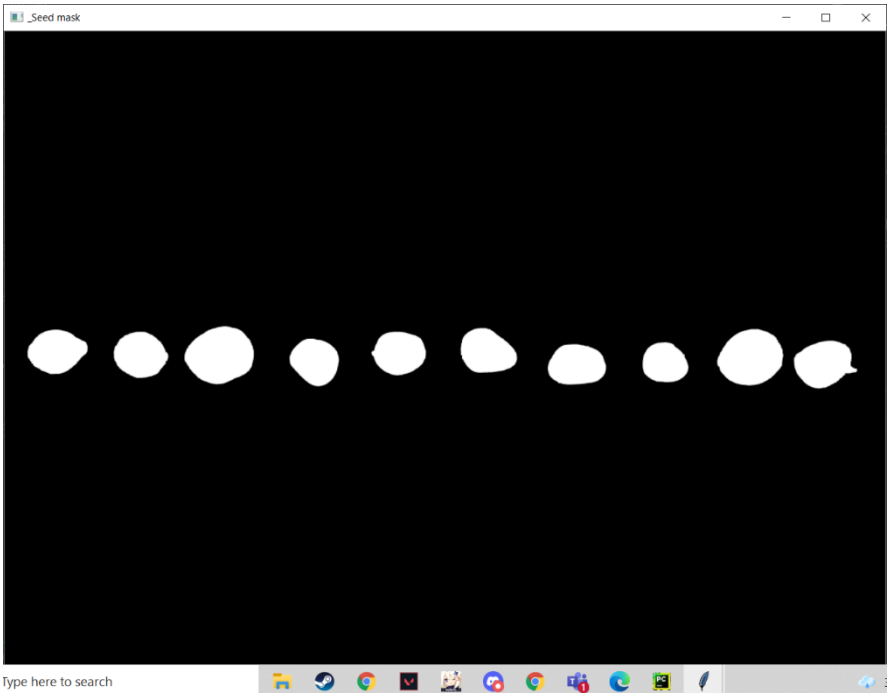


Figure 6: Seed pre-process result

Seed Segmentation

The seed segmentation algorithm uses the seed mask produced by the seed pre-process algorithm as an overlay on the input image to obtain the positions of the seeds in the input image and segmentize the seeds into bounding boxes using the seed edges obtained from the seed pre-processing.

4.3.2 Seed Prediction Algorithm

For our seed quality prediction, we will be using a prediction algorithm to classify the seeds in the processed image. The algorithm uses a pre-trained model and evaluates the seeds in the processed image based on criterions. Once the seed has been evaluated, it will be given a classification on whether it is a good seed, bad seed or unknown based on its prediction confidence score. Once the seed has been classified, a coloured bounding box will surround the edges of the seed to label its classification.

*Store result flow

4.4 Testing

The testing of the frontend and backend implementations of our program were done on the group members' personal devices with Windows Operating System and Python language installed. As we are still in the early stages of our project, we are unable to get our hands on the Raspberry Pi edge device to perform practical testing on our program.

The backend implementations of our program which includes the image processing and prediction has been tested with a sufficiently large dataset which consists of images of all good seeds, all bad seeds, a mix of both taken in various lighting conditions and image angles. The algorithms have been tested enough to produce reliably accurate and fast results.

The frontend implementation of our program which is the Graphical User Interface has been tested by a few of our group members to test the functionality of the buttons and the performance of the software. The GUI software has been tested more often after integrating the functionalities from the backend implementations and sufficient bug fixes have been done since then. The GUI is able to perform reliably without crashing and it works as intended.

4.5 Problems Faced

Missing and disproportionate GUI components

A problem faced during the development and testing of the GUI is that some buttons are missing, and the components appear to be larger for a few of our group members. A few possibilities of this happening could be due to the different display resolution or an incompatibility in the Python versions of the group members' devices with the software. This issue has been temporarily fixed by repositioning the components of the GUI to be smaller and closer to the centre of the GUI. This issue has yet to be properly addressed and will be worked on in the future.

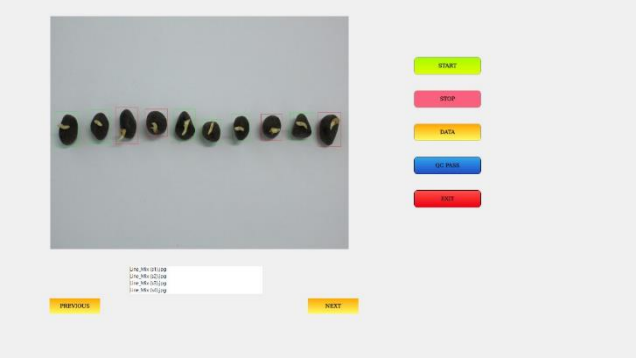


Figure 1: Intended GUI display

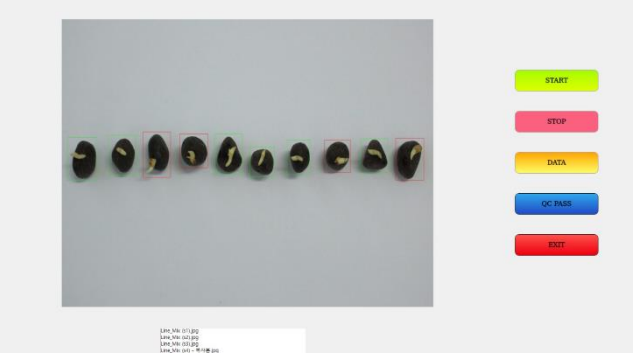


Figure 2: Problematic GUI display

5. Time Plan

This section will discuss the timeline of the events and activities that were carried out before and during the development and implementation of the system and application. The time schedule serves as a reminder or guide to the members of the group to prepare before performing specific tasks. This section will also walk through the future events planned and other activities or events the group is planning to do to complete the development and implementation of the whole system.

5.1 Work Hours Table

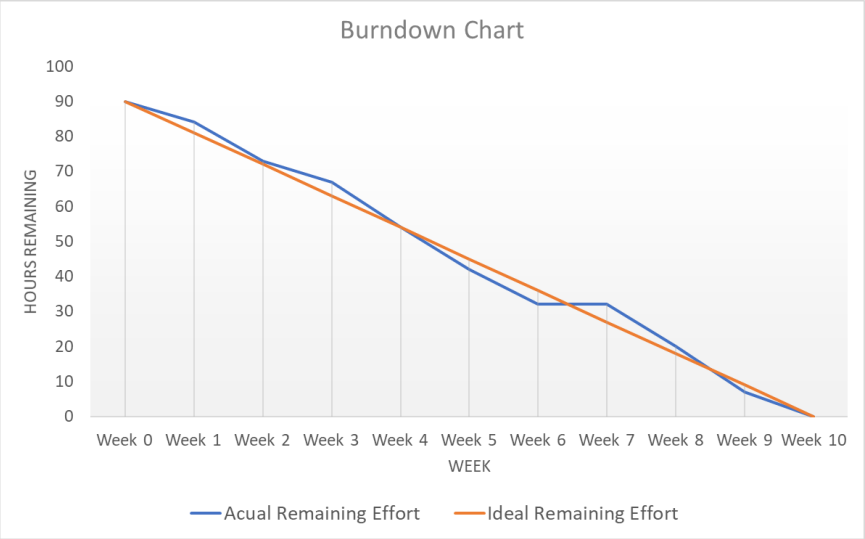
Following table includes most of the tasks that group members have worked on and achieved. For each task, the duration, start, and end date are shown on the table below.

No.	Task	Duration (hours)	Start Date	End Date
1	Research on sorting algorithm for oil palm seed	4	2/10/2021	5/10/2021
2	Reviewing requirements	2	6/10/2021	11/10/2021
3	Create a mock-up for the system layout	3	6/10/2021	7/10/2021
4	Research on Python GUI development framework	4	6/10/2021	13/10/2021
5	Further discussion of development and implementation platform	1	13/10/2021	13/10/2021
6	Setting up development environment	2	13/10/2021	15/10/2021
7	Further requirement review	2	15/10/2021	17/10/2021
8	Brainstorm on the information gathered for choosing suitable tools	2	16/10/2021	18/10/2021
9	Further discussion on tools for implementation	1	16/10/2021	16/10/2021

10	Requirements review and modification	3	18/10/2021	25/10/2021
11	Writing the interim report	18	27/10/2021	8/12/2021
12	Analysing sorting algorithm provided	10	27/10/2021	3/12/2021
13	Developing prototype application	18	27/10/2021	8/12/2021
14	Developing the GUI	10	1/11/2021	15/11/2021
15	Further clarification on provided algorithm	2	15/11/2021	15/11/2021
16	Connecting the GUI with the algorithm provided	2	21/11/2021	27/11/2021
17	Testing prototype	4	30/11/2021	5/12/2021
18	Proof-reading the interim report	2	10/12/2021	10/12/2021
TOTAL HOURS		**90**		

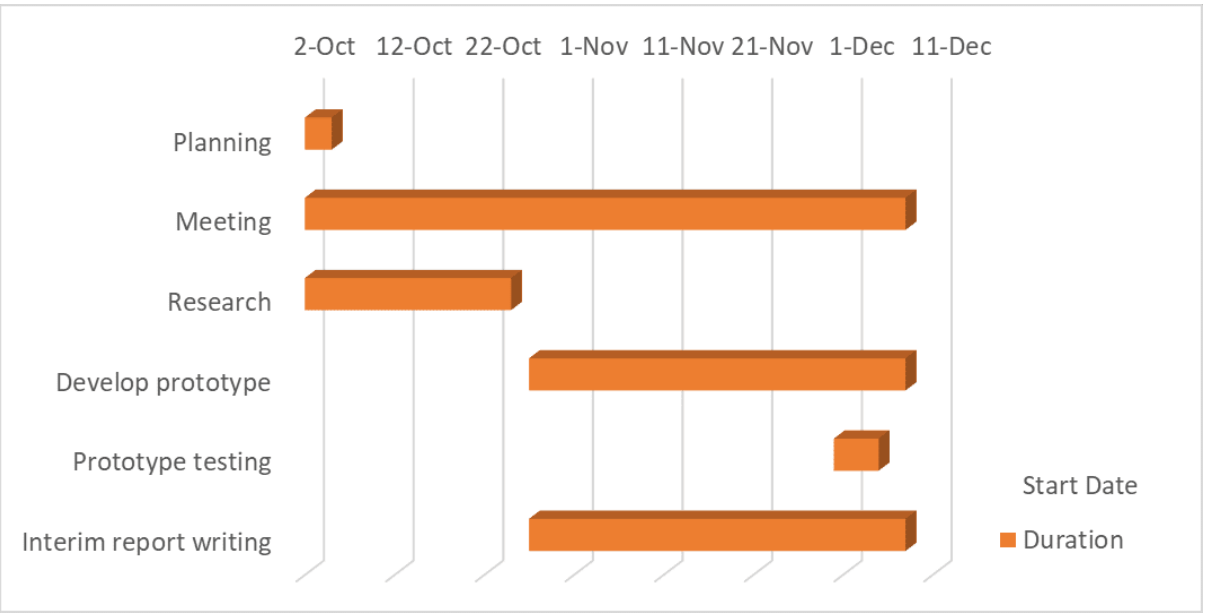
5.2 Burndown Chart

The following burndown chart relates to the work hour table in the previous section. After the first meeting with the client, the team began to get ahead of the schedule which is illustrated in the graph below.



5.3 Gantt Chart

The following Gantt chart shown the duration for each events and activities conducted for developing and implementing the project.



5.4 Future Events

In the coming semester break, our group will be sourcing various hardware parts necessary for our system which includes a camera, a Raspberry Pi, a conveyor belt, motion sensors and a projector. During this period, we will be researching on the specifications and budget that we will need as well as writing a proposal to request for funding's.

When the second semester begins, we should be able to progress on working with the hardware parts. This includes implementing the software we have into the Raspberry Pi and ensuring the necessary files and environment are ready. We will also be integrating the various external input devices such as the sensors and camera as well as output devices such as the conveyor belt and projector into our software. We plan to further develop our software to include these external devices and get ready for deployment.

Once our system has been deployed, we will be doing further testing and necessary bug fixes as well as getting further feedback from our supervisor and client before rounding up.

6. References

[1] Ritchie, H., & Roser, M. (2021). *Palm Oil*. Our World in Data. https://ourworldindata.org/palm-oil#citation.

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Appendix A: Application Screenshots

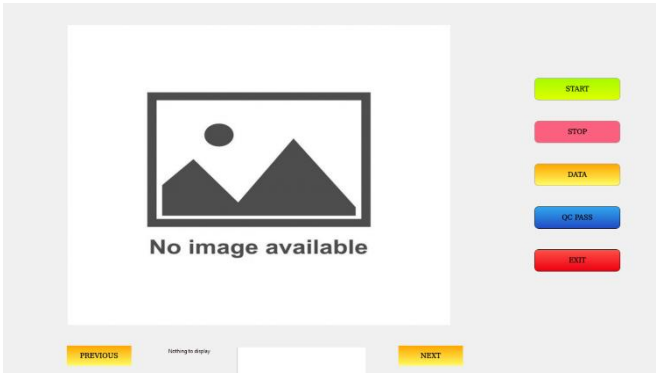

Figure 1: GUI landing page

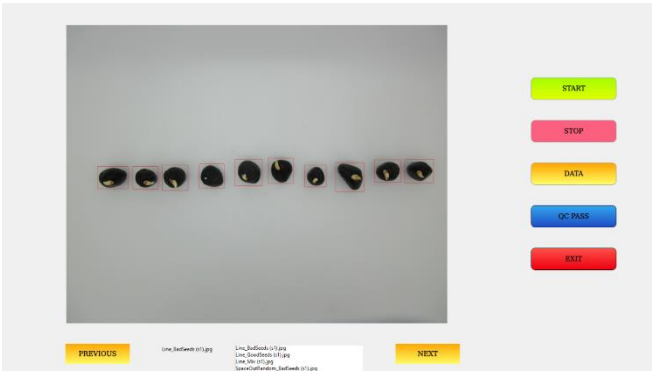

Figure 2: Display result after start

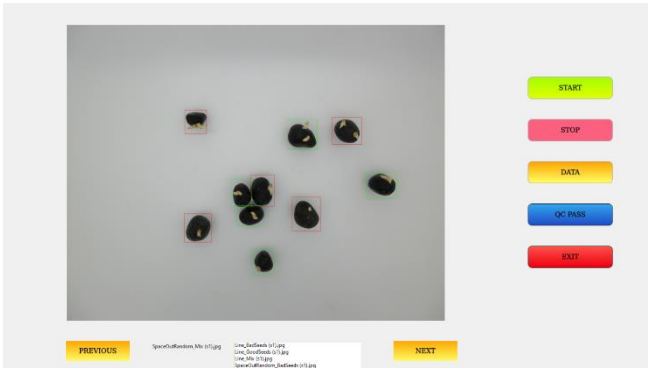

Figure 3: Display next result

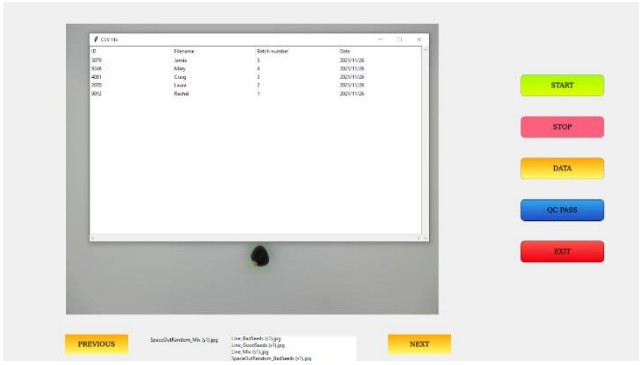

Figure 4: Display data of results

Appendix B: Meeting Minutes

Date	Attendees	Content

30 Sept 2021	All members and supervisor (Dr Iman)	• Objective
		  ○ To meet members and supervisor
		  ○ To know the objective and goals of the project
		• Discussion
		  ○ Self-introduction
		  ○ Briefing about module and project title
		  ○ Decide on project title to do

6 Oct 2021	All member, supervisor, and client	• Objective
		  ○ To know about client's backgrounds and requirements
		• Discussion
		  ○ Discuss the pros and cons of current oil palm seeds sorting system
		  ○ Method to increase productivity
		  ○ Discuss about system design
		• To do
		  ○ Further research on project title

9 Oct 2021	All member	• Objective
		  ○ Discuss on client's requirement
		  ○ Discuss the structure of the project description report

		• Discussion
		  ○ Discuss the outline and content of project description report
		  ○ Analyse the requirement from the client's and design the structure of the system and model.
		
		• To do
		  ○ Further research on project title
		  ○ Writing draft for project description report

11 Oct 2021	All member and supervisor	• Objective
		  ○ Discuss on client's requirement
		  ○ Discuss a rough idea on system design
		
		• Discussion
		  ○ Discuss and brainstorm about the research that we have done
		  ○ Create a draft model of system design based on eggs sorting system.
		
		• To do
		  ○ Further research on project title
		  ○ Working on the project description draft

16 Oct 2021	All member, supervisor, and client	• Objective
		  ○ Further discuss about client's requirement
		  ○ Getting information for writing project description

		• Discussion
		  ○ Present rough idea of system design and model
		  ○ Clients provide feedback on the idea and model.
		  ○ Supervisor gives a guide on the report writing
		• To do
		  ○ Research on the system to implement

18 Oct 2021	All member	• Objective
		  ○ Discuss about project description report
		• Discussion
		  ○ Decided on the content of the project description report to write
		• To do
		  ○ Drafting project description

20 Oct 2021	All member and supervisor	• Objective
		  ○ Project Description Review
		• Discussion
		  ○ Discuss on the content to include in project description report
		  ○ Discuss on the progress in project description report
		• To do
		  ○ Finalise and review of the project description report

27 Oct 2021	All member	• Objective
		  ○ Discuss and finalize the version of system design
		• Discussion
		  ○ Decided about the tools and software for system design and implementation
		• To do
		  ○ Explore Python toolboxes
		  ○ Explore the machine learning toolboxes

28 Oct 2021	All members and supervisor	• Objective
		  ○ Discuss on sorting algorithm provided
		• Discussion
		  ○ Supervisor gives explanation on the algorithm provided.
		  ○ Give a demo run on the algorithm
		  ○ Further explain on the project title
		• To do
		  ○ Run and modify the code to implement to the system designed

3 Nov 2021	All members and supervisor	• Objective
		  ○ Further discuss on sorting algorithm provided
		• Discussion
		  ○ QnA session for clearing the doubt
		  ○ Supervisor provides a details explanation to the algorithm

		• To do ○ Learning the code and understand the algorithm provided

5 Nov 2021	All members, Dr Aazam and supervisor	• Objective
		  ○ Discuss about edge device for the project
		• Discussion
		  ○ Dr Aazam provides the information about tools and methods to implement edge device
		  ○ Dr Aazam and supervisor provide a guideline and explain about the details on the implementation stage
		• To do
		  ○ Start to implement the system

15 Nov 2021	All members and Mr Chin Jun Yuan	• Objective
		  ○ Discuss about IDE to run the code
		  ○ Discuss about method to train model
		  ○ Further discuss on the sorting algorithm provided
		• Discussion
		  ○ Type of implementation
		  ○ Mr Chin provided and explained about the Python tools such as Pytorch and TensorBoard for machine learning
		  ○ Mr Chin provided a guide on the sorting algorithm provided
		  ○ Clarification on seed sorting algorithm.

		• To do ○ Modify the file path in the code to read the file and image processing the images read

22 Nov 2021	All members	• Objective
		  ○ Discuss interim group report
		  ○ Review on system implementation
		• Discussion
		  ○ Decided on the content in the interim group report
		  ○ Separate the job for each of the members.
		  ○ Progress update on the GUI design
		• To do
		  ○ Complete the part assigned for the interim group report

4 Dec 2021	All members and Client	• Objective
		  ○ Discuss and review on the first prototype of the system design
		• Discussion
		  ○ Show and demonstrate to client the first prototype
		  ○ Ask for suggestion for implementation
		  ○ Client provides feedback on the first prototype

		• To do
		  ○ Planning for next stage of the implementation
		  ○ Complete the interim group report

6 Dec 2021	All members	• Objective
		  ○ Update and merge the interim group report.
		
		• Discussion
		  ○ Review on interim report draft.
		  ○ Merging the group work.
		
		• To do
		  ○ Modify and adding the content in the interim report.

10 Dec 2021	All members and supervisor	• Objective
		  ○ Review and discuss the interim group report with the supervisor.
		
		• Discussion
		  ○ Supervisor provides feedback on the interim report, especially the literature review section.
		  ○ Finalize and review the interim report with the group members.