2020

SOFTWARE REQUIREMENTS SPECIFICATION FOR AUTOMATED DEFECTION DETECTOR Version 3.0

Prepared by
Group-6(Foxtrot) Sec-A
Sumaiya Kashmin Zim(201814016)
Zannatul Ferdous(201814024)
Eusha Khan(201814032)
Fardeen Ashraf(201814046)
Md. Shahir Zaoad(201814058)

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1. Preface:

Defining quality in food production is, arguably, one of the most widespread and complicated issues to solve when new products are released in the market. In short, food quality can be defined as the characteristics of food that are between certain limits of acceptance in every step of manufacturing, from the raw materials to the acceptance of consumers. Usage of computer science in terms of grading raw materials in our country is still not that popular in industrial levels. Our project aims to create a detector of freshness and defection for grading general raw fruits or vegetables for industrial use. This document contains the entire system architecture and model of the system as well as the scope and requirements of the system functionality.

2. Introduction:

2.1. Purpose:

One of the biggest problems in the food industry is that it faces food spoilage specially in case of vegetables and fruits. The bigger problem is these spoilt items are going undetected and onto the hands of the consumer. In many fruits and vegetables industries, the process of checking of quality of items is done manually, mostly by a person sitting across a conveyor belt as the items pass by. The target of this project is to establish an efficient automated process which would not only increase the accuracy of spoilt food detection, but also reduce manual manpower required.

2.2. Intended Audience:

This project will provide an automated food freshness detector and the main audience is intended for the food industry. It will be useful for the industries as it decreases human dependency in industrial level food grading and replace it with machine dependency for better output of quality grading

2.3. Product Scope:

Fruit freshness grading via computer vision technology exploits on the fruit texture, colour and shape for visual feature evaluation. The whole system will work on identifying the raw and stale elements and separate them from the fresh ones. This project will work using some specific food and vegetables (Apple, Banana, Mango, Tomato). All system information will be maintained in a database. The system is designed to use as few people as possible and get higher production rate and product quality.

3. Glossary:

CNN model: Convolutional Neural Networks (CNNs) is the most popular neural network model being used for image classification problem. The big idea behind CNNs is that a local understanding of an image is good enough.

VGG model: VGG is a convolutional neural network model which achieves 92.7% top-5 test accuracy in ImageNet, which is a dataset of over 14 million images belonging to 1000 classes. VGG also outperforms baselines on many tasks and datasets outside of ImageNet.

Computer vision: Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and videos and deep learning models, machines can accurately identify and classify objects — and then react to what they “see.”

Saliency map: In computer vision, a saliency map is an image that shows each pixel's unique quality. The goal of a saliency map is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.

OpenCV: OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products.

Jetson Nano: Jetson Nano is a small, powerful computer that lets one run multiple neural networks in parallel for applications like image classification, object detection, segmentation, and speech processing. All in an easy-to-use platform that runs in as little as 5 watts. Windows isn't officially supported on Jetson. The official operating system for the Jetson Nano is the Linux4Tegra, based on Ubuntu 18.04.

4. Requirements Discovery:

4.1. We found several articles and journals related to automated food inspection and studied them in order to have a clear understanding of the requirements a project like this should be able to fulfill.

4.2. We conducted an online meeting with the CEO, ICT of Pran-RFL group to discuss the requirements of such project on industrial level

4.3. A google form was created and provided during the online meeting and also to some other officials who are related to this field.

5. User Requirements:

5.1. The system should be able to identify stale and defected raw materials.

5.2. The system should be able to separate the stale and raw materials from the fresh ones.

5.3. The system should be user friendly.

5.4. System should have enriched and versatile database of apple, banana, mango, tomato.

5.5. The system should need the least amount of human inspection during the automated process.

6. System Architecture:

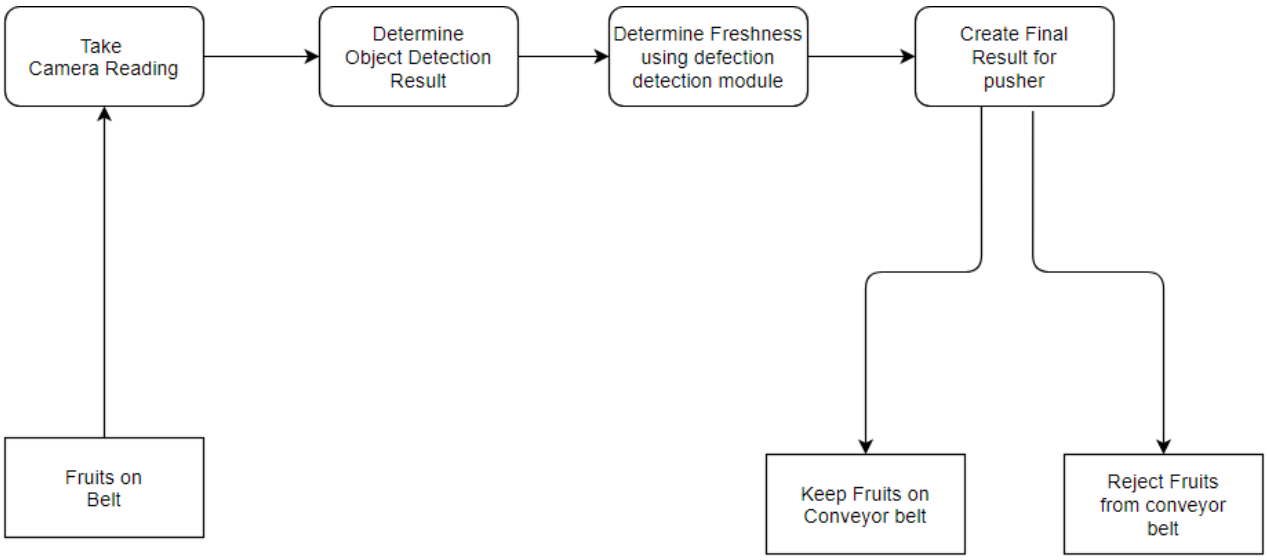


Fig: System Architecture

A pipe and filter architecture is taken into consideration as the system takes minimal user inputs during the process rather works upon a dataset initially provided .

7.System Requirements Specification:

7.1. System Requirements:

7.1.1. The system should be able to identify stale and defected raw materials.
7.1.1.1. An automated food detection system will be used to identify defected or rotten fruits by itself using image recognition and computer vision models.
7.1.1.2. Two raspberry pi's consisting of usb web cameras and pi cameras will be used to take readings for object detection and freshness detection.

7.1.1.3. Machine Learning will be used for increasing the capability of image recognition and defect detection system.

7.1.2. The system should be able to separate the stale and raw materials from the fresh ones.
7.1.2.1. A conveyer belt will be used to deliver the fruits and vegetables in a single column which will be headed directly for the freshness detection process.
7.1.2.2. A servo motor will be used with the alignment of conveyer belt and 2nd raspberry pi to take out any fruits and vegetables from the belt which doesn't meet the desired freshness value.

7.1.3. The system should be user friendly.
7.1.3.1. A user will be able to put the vegetables & fruits on the conveyer belt easily.
7.1.3.2. The system will be built on raspberry pi which will enable users to make changes to the available options of the system by simply connecting a laptop and monitor with the pies.

7.1.4. System should have enriched and versatile database of apple, banana, mango, tomato.
7.1.4.1. Database will be used to store reference images that will be compared with input image.
7.1.4.2. A large database of these selected fruits and vegetables by user demand will already available in the system before the deployment.

7.1.5. The system should need the least amount of human inspection during the automated process.
7.1.5.1. Freshness will be measured using image recognition and CNN models with the help of images of various stages (under-ripe, ripe, over-ripe) of a single fruit/vegetable stored in the database.
7.1.5.2. The raw materials will be automatically transferred via a conveyer belt for the freshness detection process and also be separated automatically with the help of a servo motor.
7.1.5.3. The only human contact the system will need to put the raw materials on the conveyer belt and take them off from it which ensures a fully automated system with minimal human worker inspection.

7.2. Requirements Classification:

Serial No	User Requirements	Types of Requirements	
		Functional	Non-functional
01.	The system should be able to identify stale and defected raw materials	√	X
02.	The system should be able to separate the stale and raw materials from the fresh ones	√	X
03.	The system should be user friendly	X	√
04.	System should have enriched and versatile database of apple, banana, mango, tomato.	√	X
05.	The system should need the least amount of human inspection during the automated process	√	√

8. System Model:

The process of developing abstract models of our system, with each model presenting a different view or perspective of that system. The System model for the project consists of four different types of models. Those are given below:

i. Context Diagram
ii. Use case Diagram
iii. Sequence Diagram
iv. Activity Diagram

8.1. Context Diagram

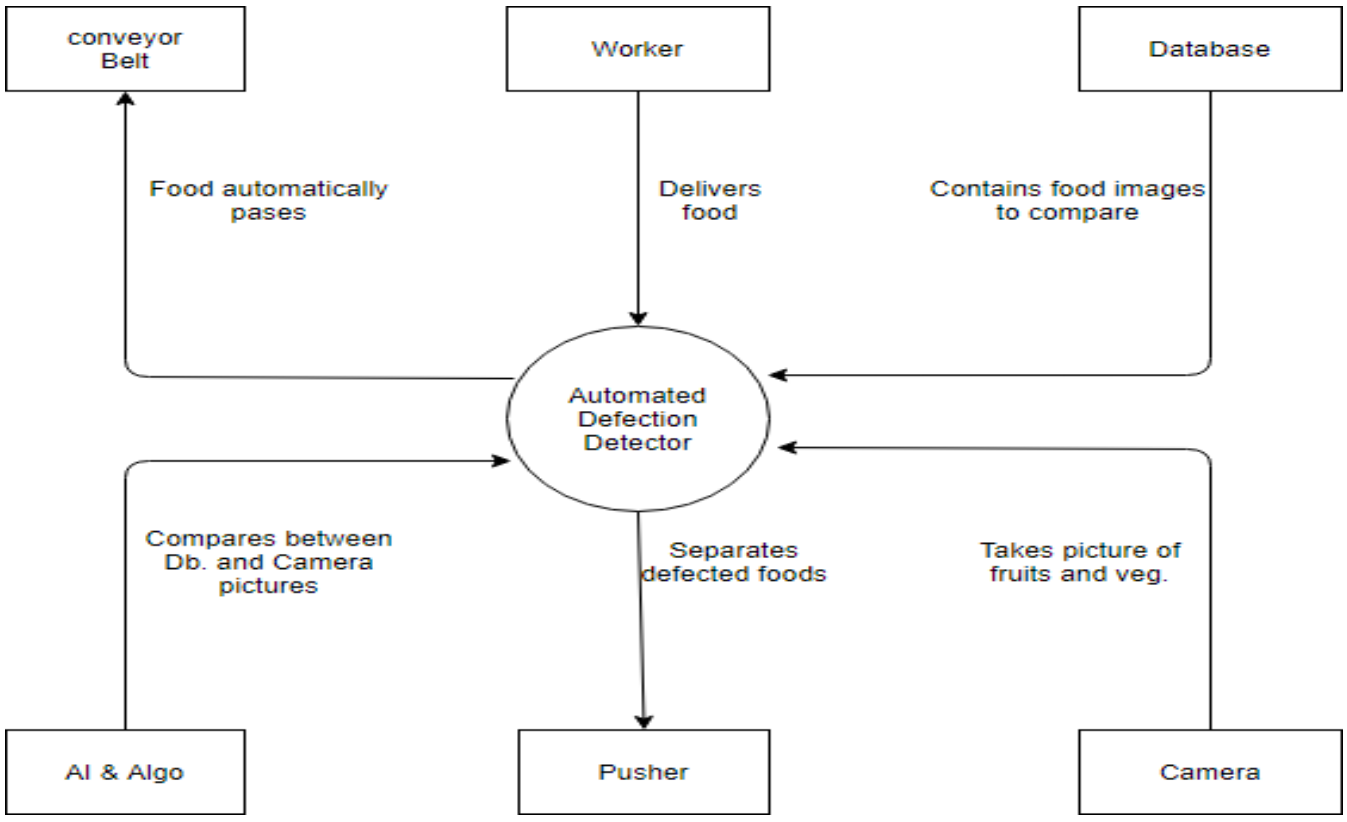


Fig: Context Diagram of Automation Defection Detector

8.2. Use-Case Diagram

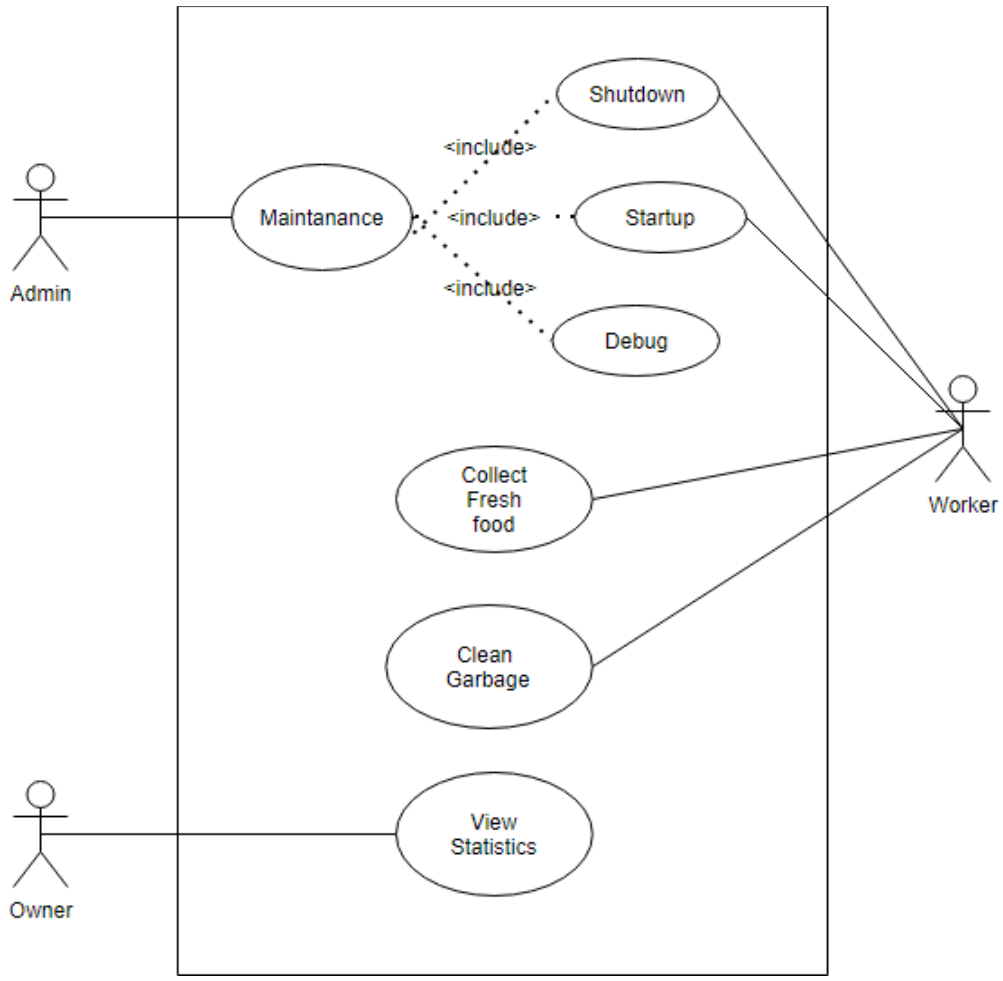


Fig: Use-case diagram for maintenance

Actors	Admin, Owner, Worker
Description	Admin will maintain the system. Owner will only view statistics. And shutdown and startup of the system will be done by worker and worker will also collect fresh food and clean garbage.
Data	Statistics data
Stimulus	Startup and shutdown command, and command to view statistics
Response	Startup and Shutdown of system at getting command
Comments	The worker must have the appropriate security permission to access the system.

Use-case diagram for Database Maintenance

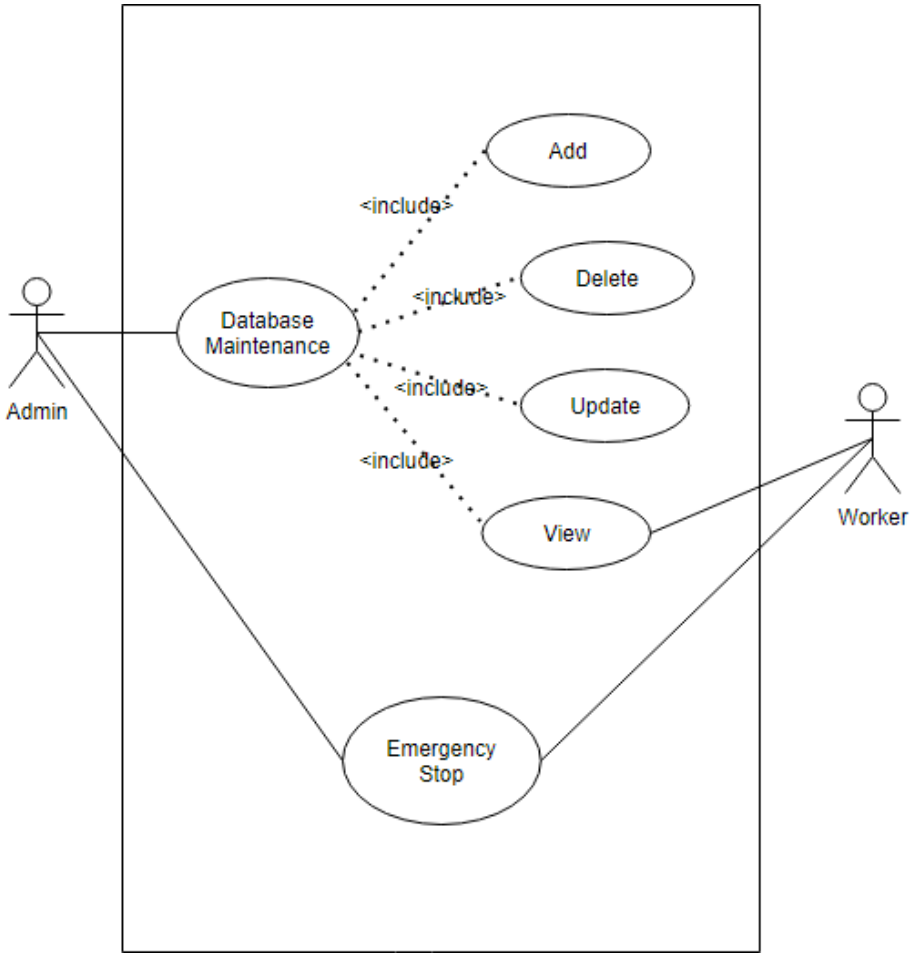


Fig: Use case diagram of freshness detection system

Actors	Admin and Worker
Description	Admin will maintain the database and in case of emergency he will be able to stop the system. Worker will also be able to stop the system in emergency situation.
Data	Collection of food images
Stimulus	By user command emergency stop will occur. And using query admin can add, delete, update or view database.
Response	Database will response to query and system will stop at emergency stop command.
Comments	The worker must have the appropriate security permission to access the system.

8.3. Sequence Diagram

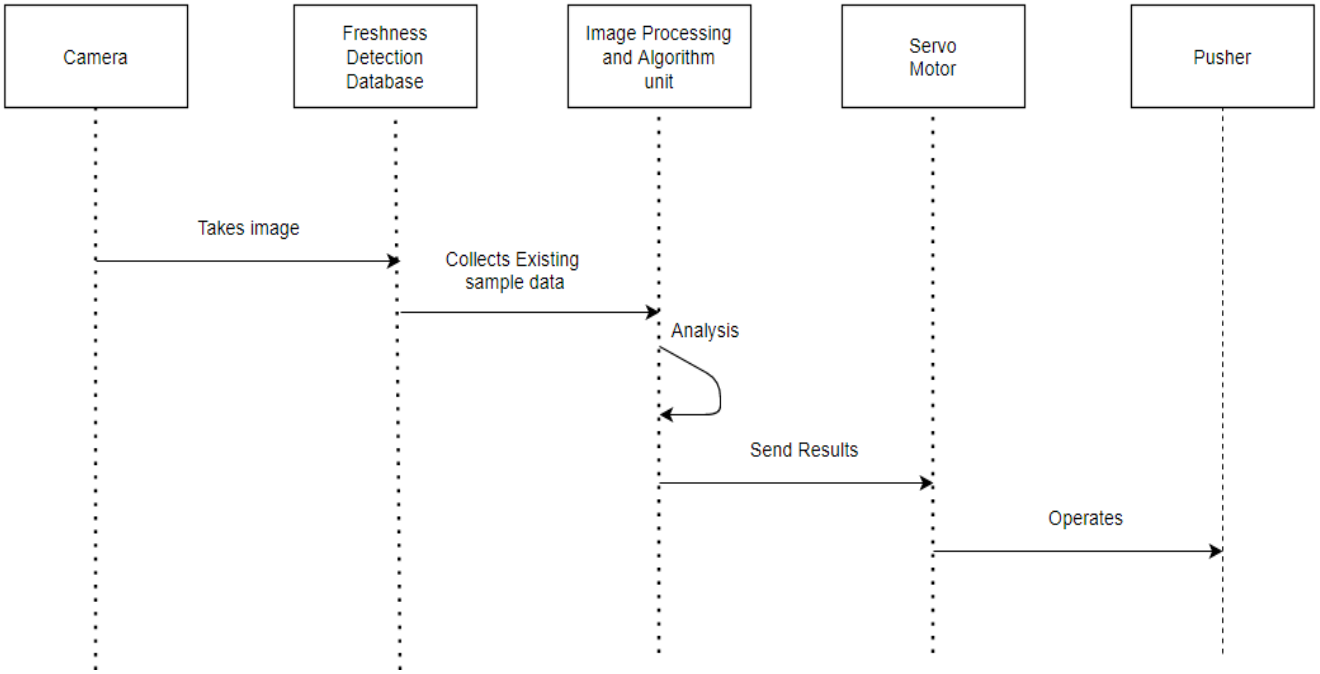


Fig: Sequence diagram of detection mechanism

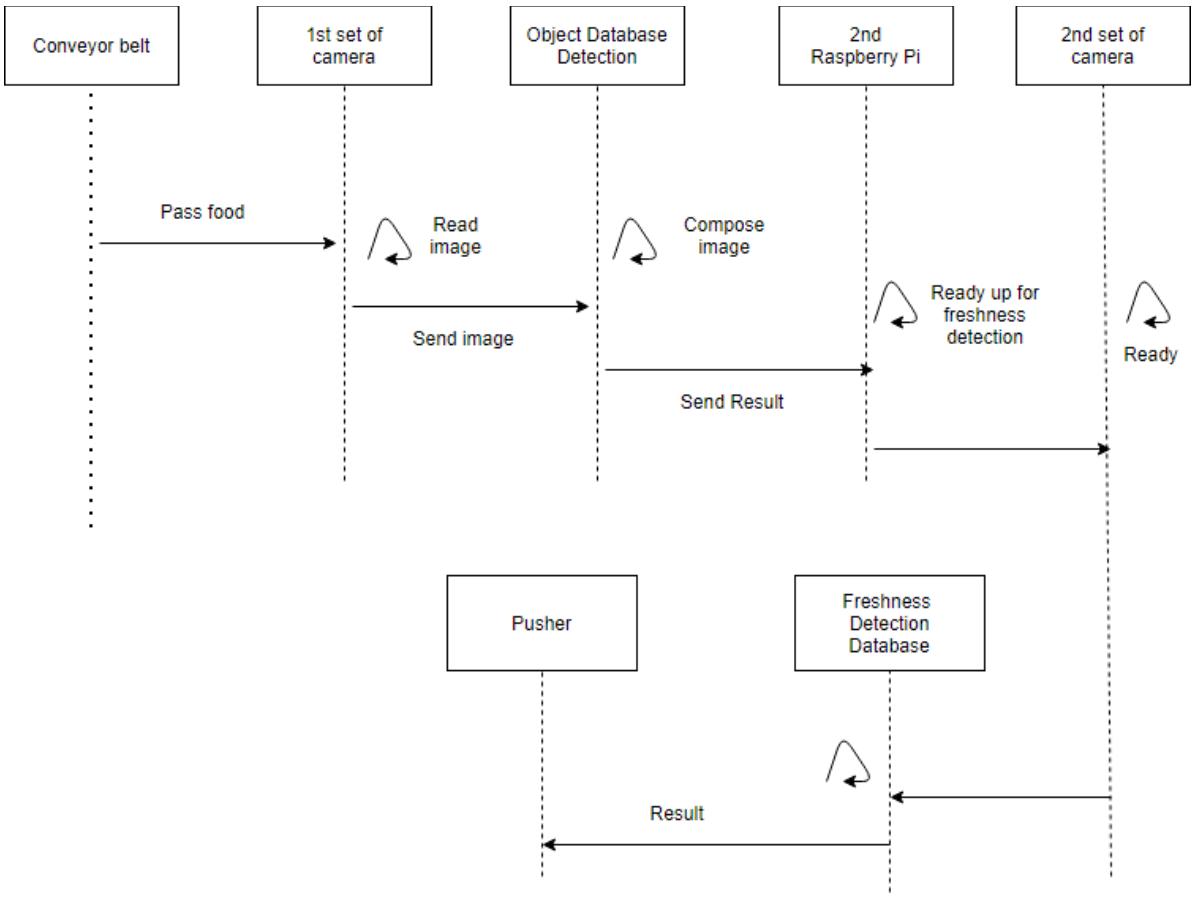


Fig: Sequence diagram of total system

8.4. Activity Diagram

Diagram of system with first Raspberry pi:

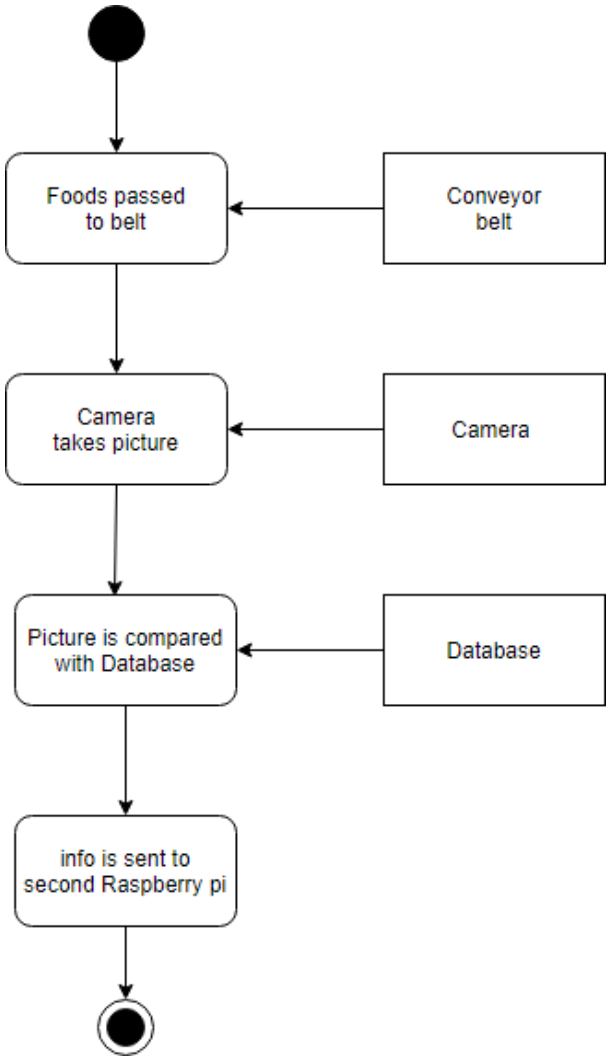


Fig: Activity Diagram of 1st Raspberry-pi system

Activity Diagram with Second Raspberry-pi system:

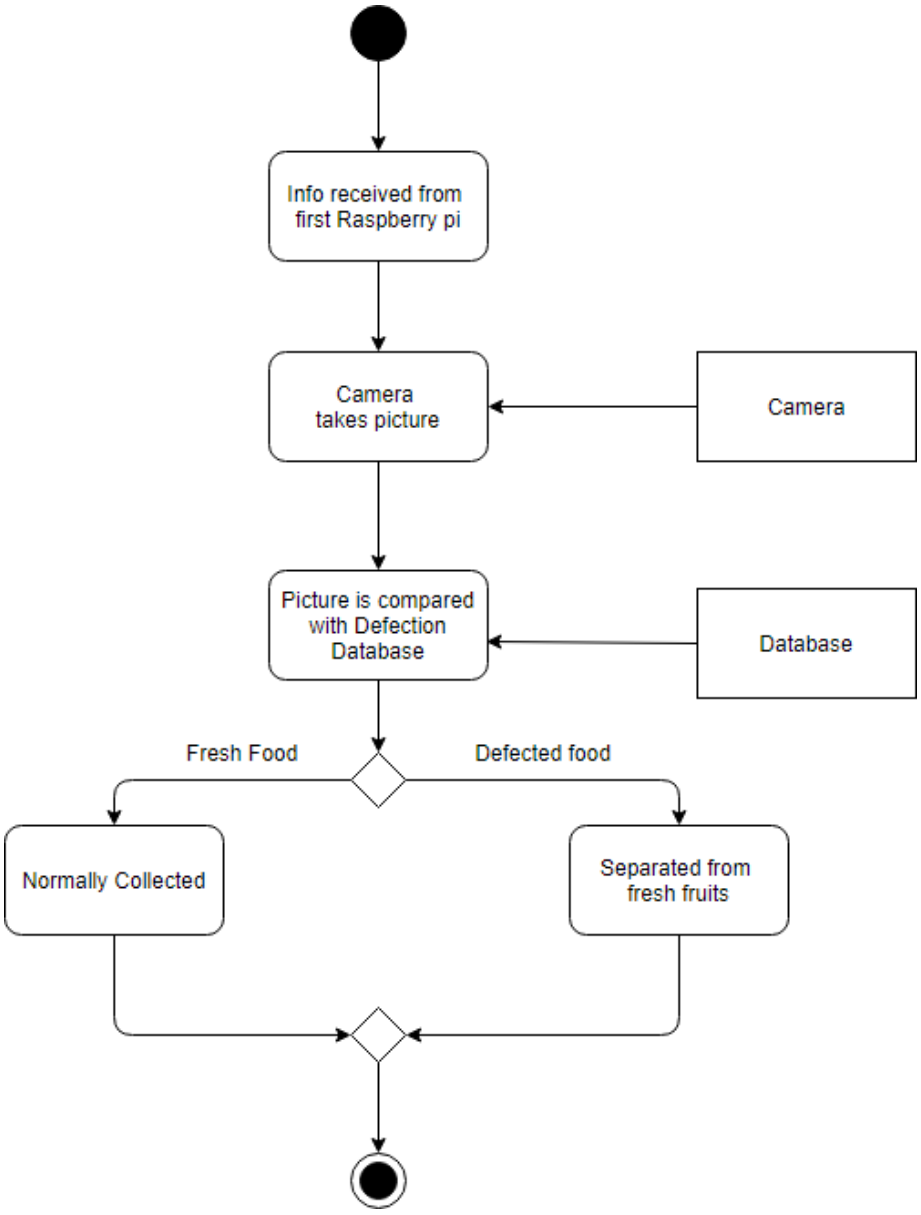


Fig: Activity Diagram with 2nd Raspberry-pi system

8.5. Data Flow Diagram:

Scenario 1:

Owner/Authorized worker accesses the website. Navigate to hardware control section. Enables conveyor belt, camera, and servo motor. Then workers started to place fruit in the belt for separation process.

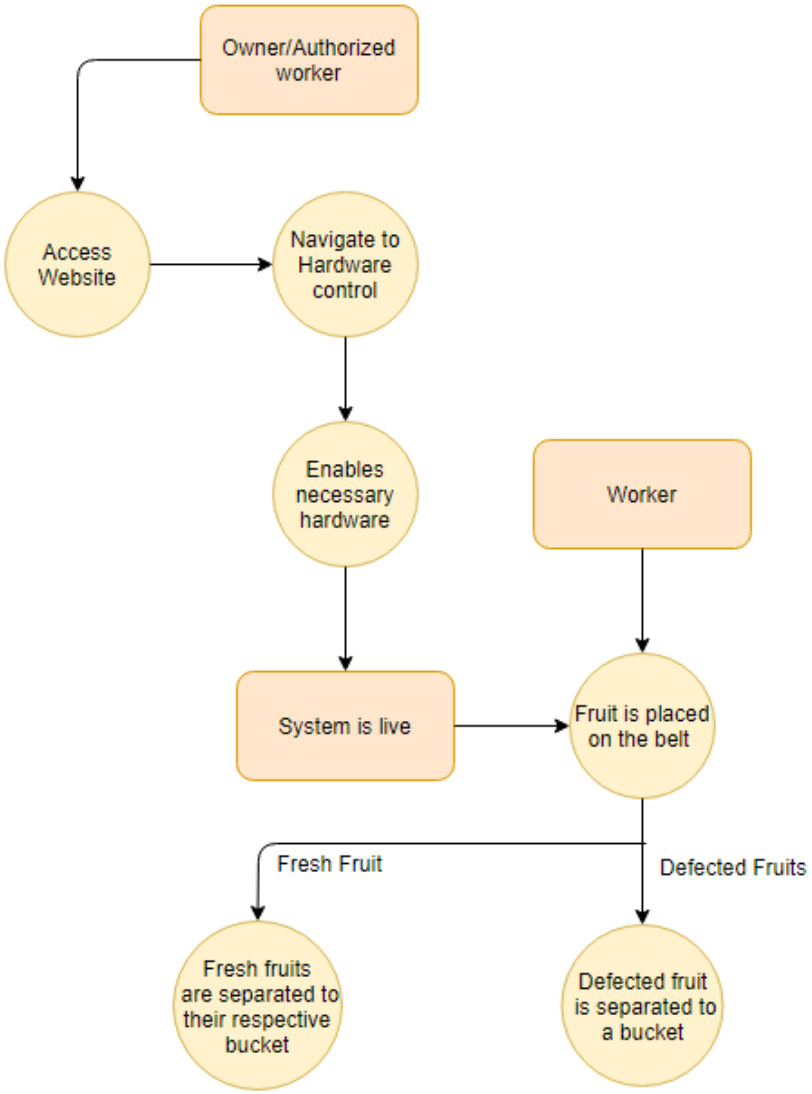


Figure: DFD of Scenario 1

Scenario 2:

Owner logins to the website. Go to the statistic page. Enter the date of which he wants to view the total amount of fresh/defected food. The query shows the result of all the fresh/defected food of that day.

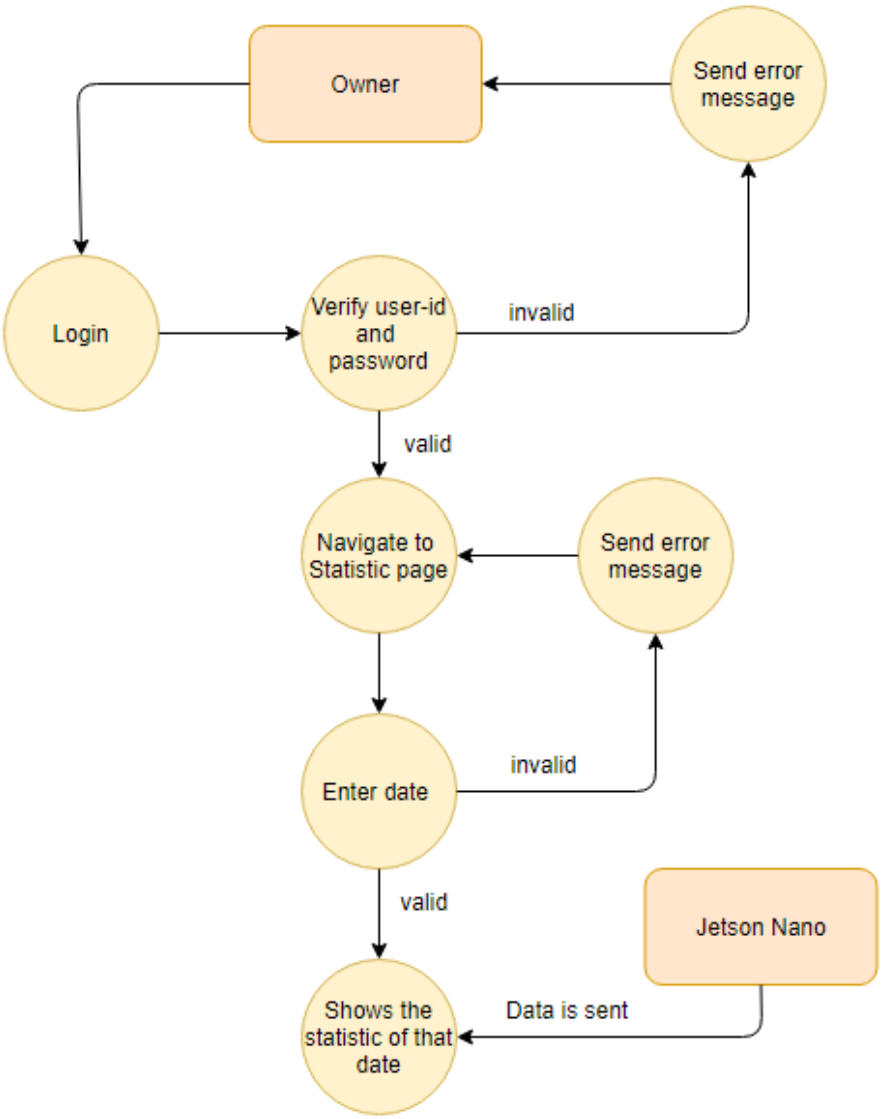


Figure: DFD of Scenario 2

9.System Evolution:

9.1. Some users preferred a real time data feedback from our system during the detection process. A general mobile or computer UI can be developed in future which will enable the admins or managers related to this process to view real time data of how many batches of fruits are being processed, what are the defection amount and also if any bug or technical fault arises in the system the admin will be notified in real time via the UI.

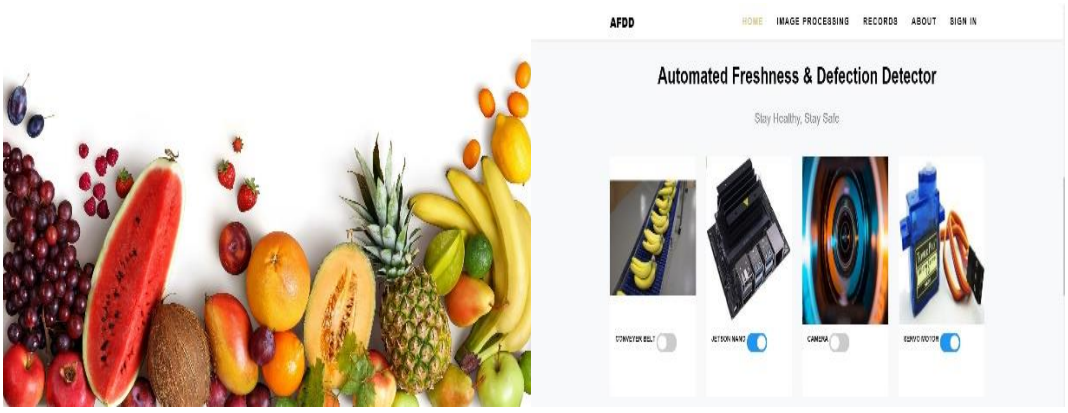
9.2. Some companies do not use large scale conveyor belt food processing because of their lack of infrastructure and budget, but they do need to process the raw materials somehow and mostly rely on human workers. For small scale users like this our system can be integrated into a web application, where all the features will work just as intended except the pusher.

10. Special Requirements:

10.1. User Interface:

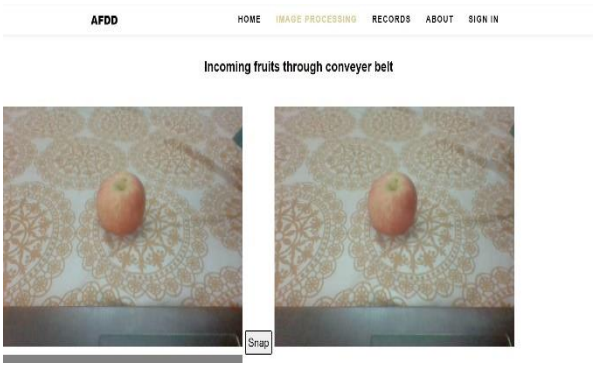
10.1.1. Home Page:

The home page is the hardware component's control section (ON/OFF).



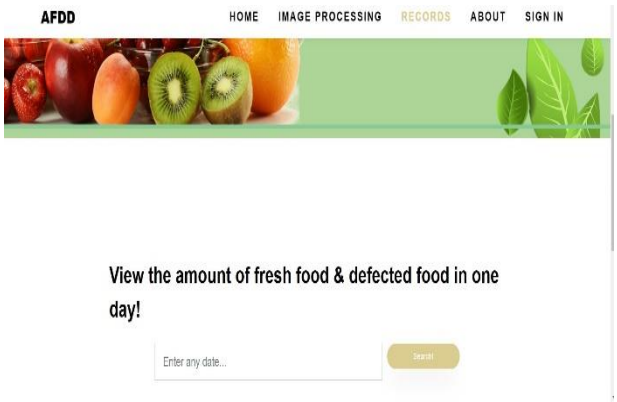
10.1.2. Image Processing:

Both worker & owner have the access to this page. This is a live feed. Here the foods that are incoming through conveyer belt will be seen serially.

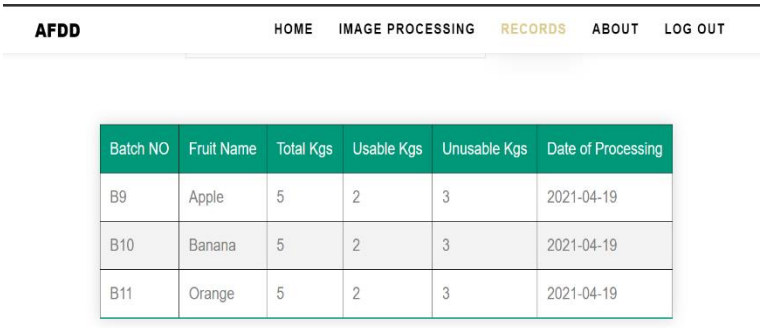


10.1.3. Records:

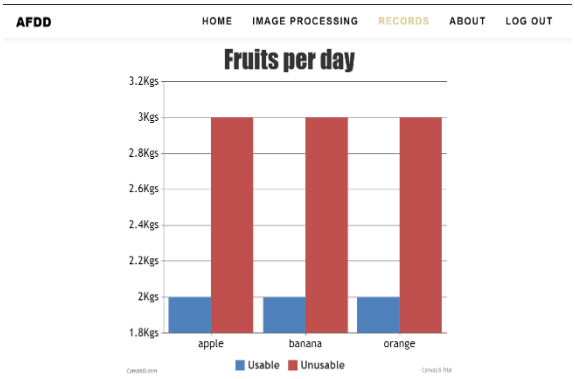
Only owner will have the access to Statistics page. Owner can view the amount of fresh food & defected of any particular day. This page will retrieve the data from the database.



This is how the Statistics page looks like after owner selecting any particular day. In the UI design this page is not shown.



Batch NO	Fruit Name	Total Kgs	Usable Kgs	Unusable Kgs	Date of Processing
B9	Apple	5	2	3	2021-04-19
B10	Banana	5	2	3	2021-04-19
B11	Orange	5	2	3	2021-04-19

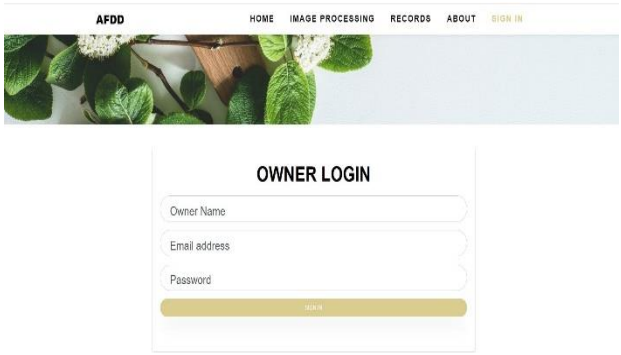


10.1.4. About:

The about page is kept so that new worker can understand the system easily. It also shows the purpose of the whole system.

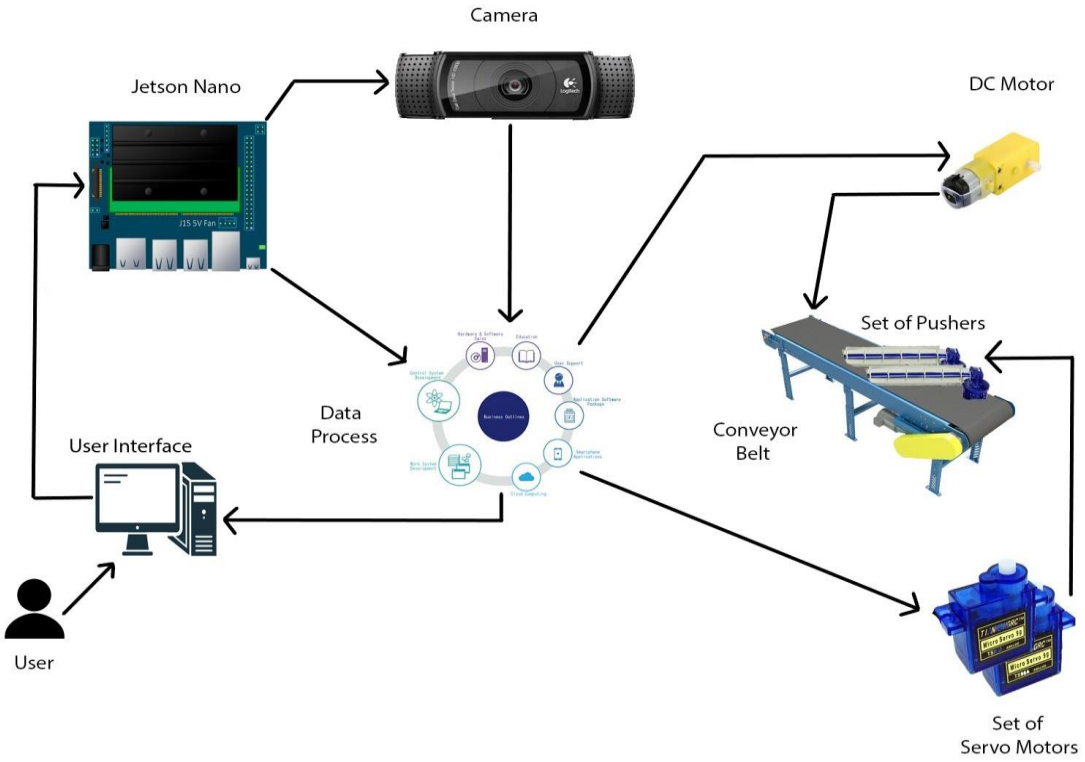
10.1.5. Sign in:

The username, email address and password are stored in the database. The page retrieves the credentials and work in session.



10.2. Hardware Interface:

Jetson Nano is used as the main brain here. The dc gear motor controls the rotation speed of the belt in conveyor belt. Fruits will be placed on conveyor belt at a specific distance. When the web cam will find a moving object, it will capture the object and send it for required classifications. After classifications, the fresh fruits will be pushed to their specified basket and the defected fruits will be pushed to the defected labeled basket. This pushing process will be controlled by the servo motor.



Automated Freshness and Defection Detector

11.Appendices:

11.1. Survey:

The form consists these following questions:

11.1.1. Does your company have any automated raw material inspection system?

11.1.2. If No,

- What are the barriers for implementing such system in your company?
- From your company's point of view does the technology seem less feasible or less cost efficient or both?

11.1.3. If Yes,

- Does the system heavily rely on image recognition process?
- Is your system fully automated or needs to be inspected by

human worker in some degree?

- How the ineligible raw materials handled after going through the inspection system?
- What are the types of fruits your system can inspect automatically?

The link of form which was used in discovering the requirements of the system:

https://docs.google.com/forms/d/e/1FAIpQLSfzuPFfzRLfeoNJdpaCKpjRvVWJKOU9XeS2OAJ1Ryt4gHQTGQ/viewform

11.2.References:

Reference paper links for which were studied during requirements discovery are given below :

[1] A. Bhargava and A. Bansal, “Fruits and vegetables quality evaluation using computer vision: A review,”05-Jun-2018. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S131915781830209X?fbclid=IwAR1egn1Axdez8ruhxNBuMnUVrr3DYE1GnzgVPfBP_9KU2gh399G8Lwyvdrs.

[2] “Fruit and vegetables classification system using image saliency and convolutional neural network,” *Fruit and vegetables classification system using image saliency and convolutional neural network - IEEE Conference Publication*. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8122370/.

[3] I. B. Mustaffa and S. F. B. M. Khairul, "Identification of fruit size and maturity through fruit images using OpenCV-Python and Rasberry Pi," 2017 International Conference on Robotics, Automation and Sciences (ICORAS), Melaka, 2017, pp. 1-3, doi: 10.1109/ICORAS.2017.830806

[4] https://irjmets.com/rootaccess/forms/uploads/fruit-freshness-detection-using- cnn-approach.pdf