Subject Code: BITI1113

Subject Name: Artificial Intelligence

Lecturer Name:

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Group 28

Topic: FarmIntel: Fruit & Vegetable Disease Detector

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Table of Contents

Part A: Problem Statement

Background

In agriculture, the post-harvest quality and health of fruits and vegetables is extremely important. A challenge faced by food producers, retailers, and consumers is being able to find disease or rot in produce before it expands and causes a lot of waste. The typical method involves farmers looking at the produce and inspecting it for damage or rot, using their eyes as their only tools. This can waste time, be misjudged and be prone to error. Early signs of decay can often be extremely subtle and not stand out when dealing with large amounts.

With increasing demand for food safety and efficiency in the supply chain there is a shift in interest for more automated solutions that will detect disease in fruits and vegetables, at a higher accuracy. In recent years, has been advancements in artificial intelligence (AI) technology, specifically in computer vision and deep learning methods, to monitor food quality.

The project called "Smart System: Fruit and Vegetable Disease" will use a labeled dataset from Kaggle, an online platform with the recycle bits and bytes of images of fruits and vegetables categorized as healthy or rotten. By training a deep learning model to learn and recognize patterns of symptoms associated with disease, we are aiming to create a reliable and scalable system with real-time detection.

Problem Definition

Workers manually classifying quality of fruits and vegetables can be subjective, labor intensive, and variables are often inconsistent regardless of worker experience. Human inspectors can also miss some early signs of diseases, especially in stressful time-starved situations and, or poor lighting. This results in spoiled crops being sent to market, customer dissatisfaction, increased waste, and loss of economic value.

The problem is that there is no scalable, accurate, and automated way to differentiate healthy fruits or vegetables from rotten fruits or vegetables. An applied mechanism is needed to accurately inspect and process images that returns reliable diagnoses without the burdened and inherent biases of human or human touch inspections.

Objective

i. **Develop a Smart AI System**: Develop a deep learning based image classification model capable of distinguishing healthy fruits and vegetables from rotten ones.
ii. **Enhance Post-Harvest Processing**: Allow for automated quality control in packaging and sorting lines.
iii. **Reduce Food Waste**: Catch spoiled produce early in the supply chain before they can deteriorate surrounding items.
iv. **Improve Food Safety**: Provide assurance for consumers that produce are fresh and of quality.
v. **Support Agricultural Technology**: Provide the basis for smart farming and precision agriculture frameworks.

Sustainable Development Goals (SDG 12)

The FarmIntel project aims to create an AI-powered system that can detect diseases in fruits and vegetables. This aligns strongly with SDG 12, which seeks to ensure sustainable consumption and production patterns. Our project contributes to this goal in several impactful ways:

1. **Reducing Food Waste**

- By spotting spoilage and disease in produce early, our system stops rotten items from contaminating healthy ones. This cuts down on food waste in the post-harvest supply chain.
- Supports SDG Target 12.3: "By 2030, halve per capita global food waste at the retailer and consumer levels."

2. **Improving Food Safety**

- Ensures that only healthy, high-quality fruits and vegetables reach consumers by providing an objective and automated disease detection method.
- Reduces the risk of foodborne illnesses and increases consumer confidence in the food supply.

3. **Promoting Sustainable Agriculture**

- Assists farmers and distributors in maintaining produce quality through data-driven insights.
- Encourages efficient resource usage and minimizes waste from farm to fork.

4. **Enabling Automation and Efficiency**

- Replaces manual, subjective inspections with accurate AI-based systems.
- Saves time and reduces labor costs while improving operational consistency.

Target Users

The technology helps farmers track plant health throughout the life-cycle from growth through harvest phase of the crop by identifying problems at an early stage, which helps to maximize productivity and reduce waste.

Wholesalers & Distributors: automate the sorting and grading to create a consistent product while maintaining low labor costs, while also being able to manage larger volumes using automation and technology.

Retailers: check the quality of produce before selling it through their business while also tracking the freshness in their inventory management systems, while improving prices and reducing returns using freshness as a guide.

Consumers: have access to mobile applications that are helpful in monitoring the ripeness, freshness, and nutritional value of fruits and vegetables before they even buy them, while reducing food waste at home.

Government Agencies: enforce food safety programs at their checkpoints, and are able to make regulatory decisions based on their own food quality value assessments to determine whether produce is fit for market.

Agricultural Researchers: utilize the technology to monitor and study disease patterns and growth conditions for crops, to improve disease responses through data-based evidence related to growing conditions and diseases.

Part B: System Design

Facts

- The dataset contains a total of 28 folders with every folder containing a combination of healthy and rotting images for 14 variety of healthy food and vegetables, and each classified as healthy/fresh or rotting/disease

- The images reveal visual symptoms: color change, mold, bruising, and textures.

Attributes such as color, body shape, and horns.
Dataset with examples labeled as large body, coat color reddish-brown, and upward-curving horns.

Rules

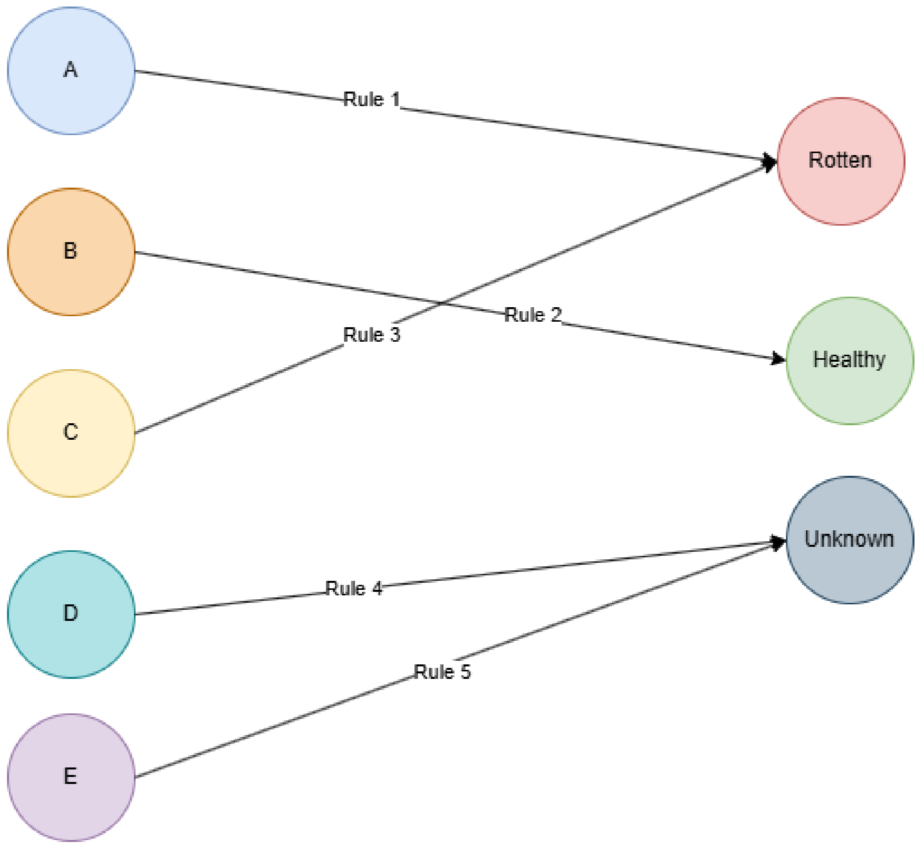
- IF the fruit is an apple AND the color changes to very dark brown and has spots on it, THEN label it as rotten apple.

- IF the vegetable is tomato AND the surface changes to a wrinkly texture with spots of mold on it, THEN label it as rotten tomato.

- IF the fruit is banana AND the peel does not show with discoloration or growing fungus, THEN label it as fresh banana.

Interference Engine

A forward chaining mechanism was implemented to classify cattle breeds based on the input attributes. The inference engine matches the input data against the knowledge base rules to generate recommendations.



Forward Chaining

Rule Legend:

- **Rule 1:**

  If the fruits or vegetables have texture anomalies, dull color and mold spots → Rotten = red color
- **Rule 2:**

  If the fruits or vegetables have intact shape, bright color and firm surface → Healthy = green color
- **Rule 3:**

  If the fruits or vegetables have irregular shape, black patches and bruising → Rotten = red color
- **Rule 4:**

  If fruits or vegetables image blurry or confidence score <= 80% → Unknown = grey color
- **Rule 5:**

  If fruits or vegetables label parsing fails or unknown status → Unknown = grey color

System Architecture

1. **User Interface**: Allows users to input attributes like colour, texture, and firmness.
2. **Knowledge Base**: Stores the facts and rules for banana ripeness classification.
3. **Inference Engine**: Processes the input attributes to classify the ripeness stage.
4. **Output Module**: Displays the classification result and actionable recommendations.

Part C: Implementation

Tools and Technologies Programming

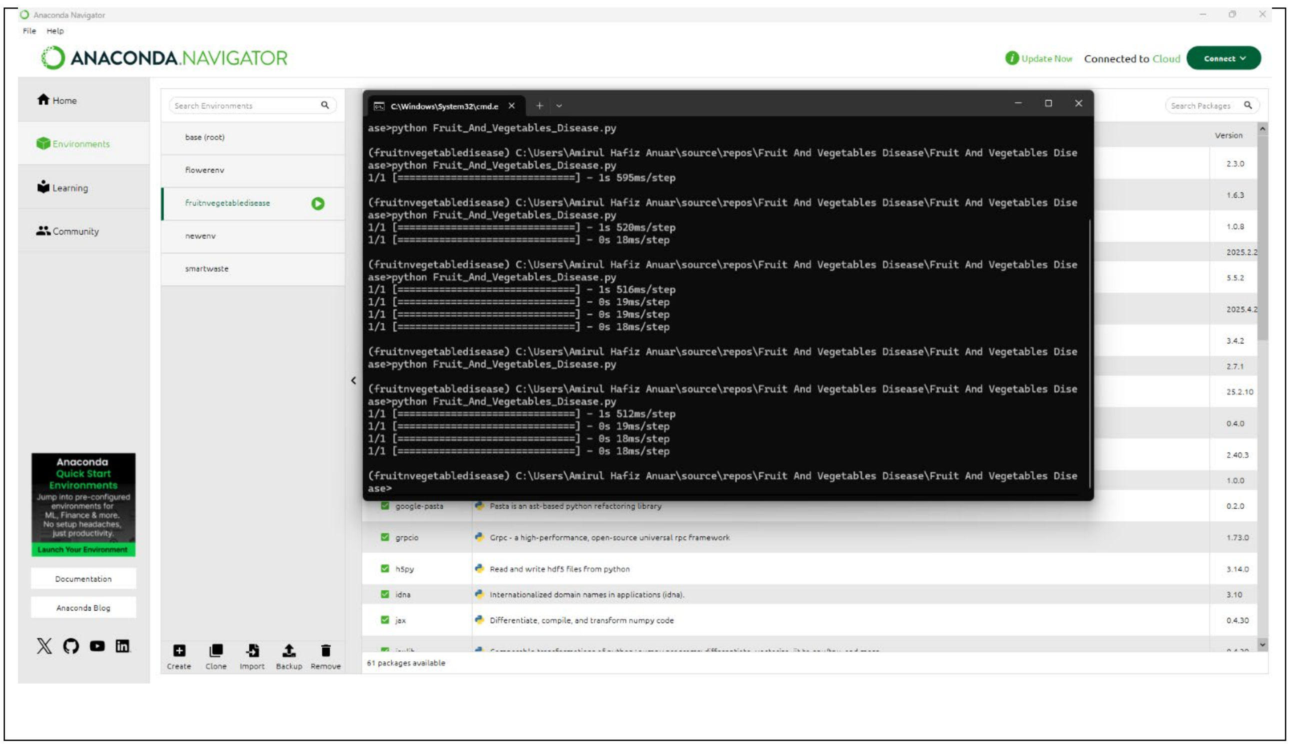
Language: Python

Compiler: Microsoft Visual Studio 2022

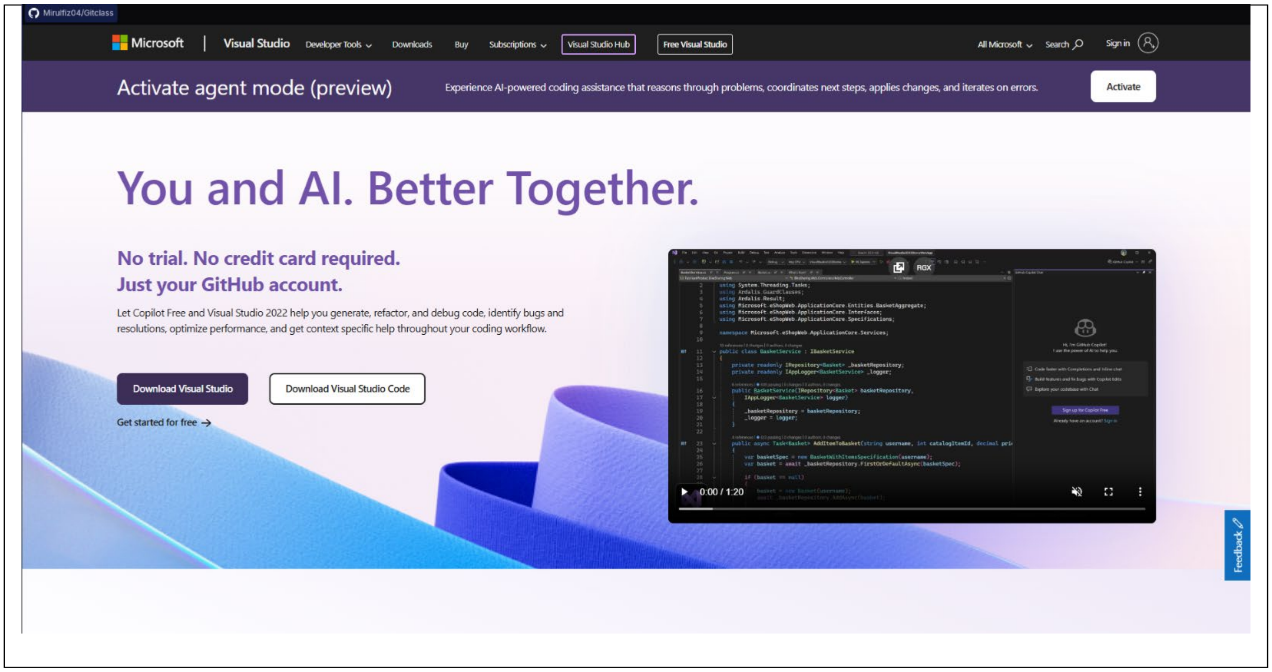
Libraries: Anaconda for the user interface, Visual Studio for development, and Teachable Machine for data handling and rule-based implementation

Development Steps

1. **Download libraries**

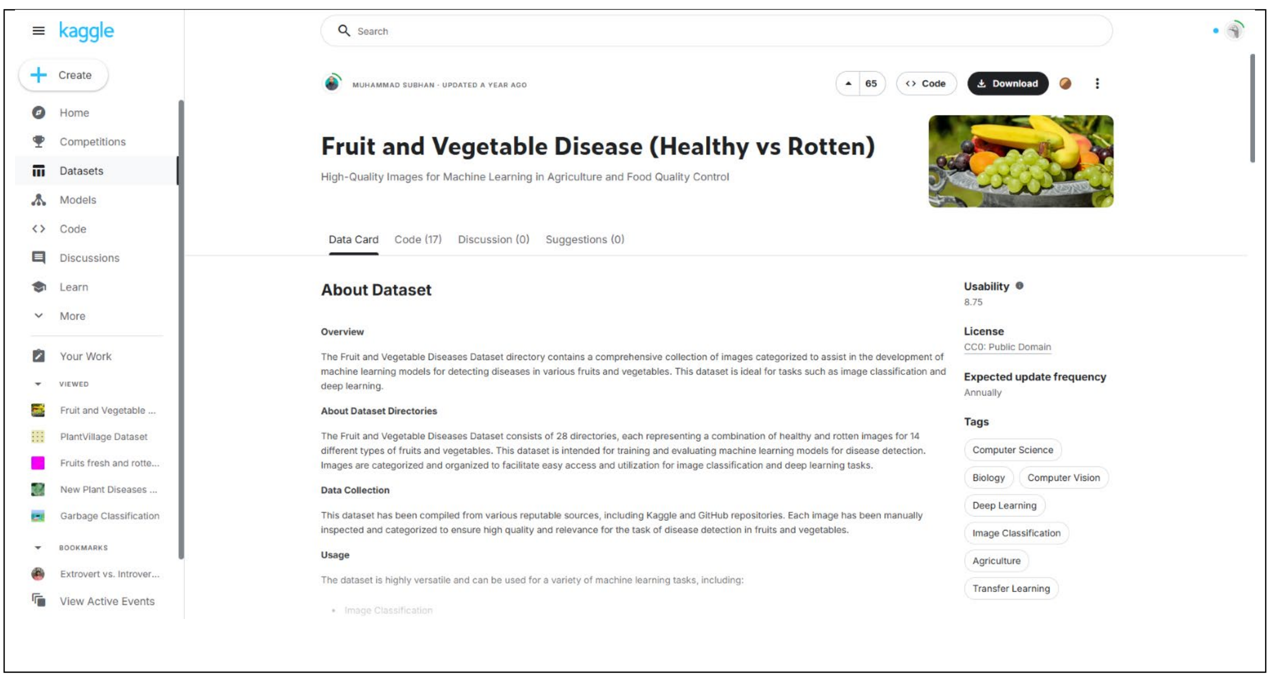


Anaconda Navigator used for management of python.



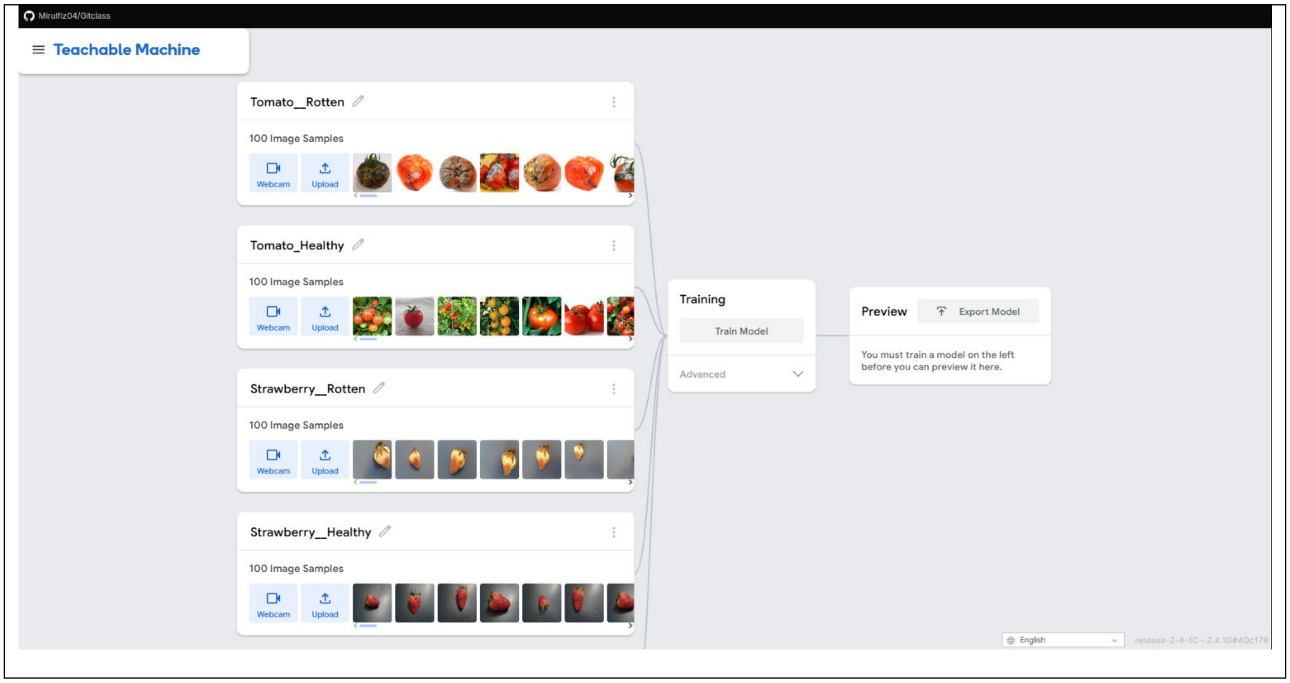
Visual Studio as code compiler

2. Data Collection



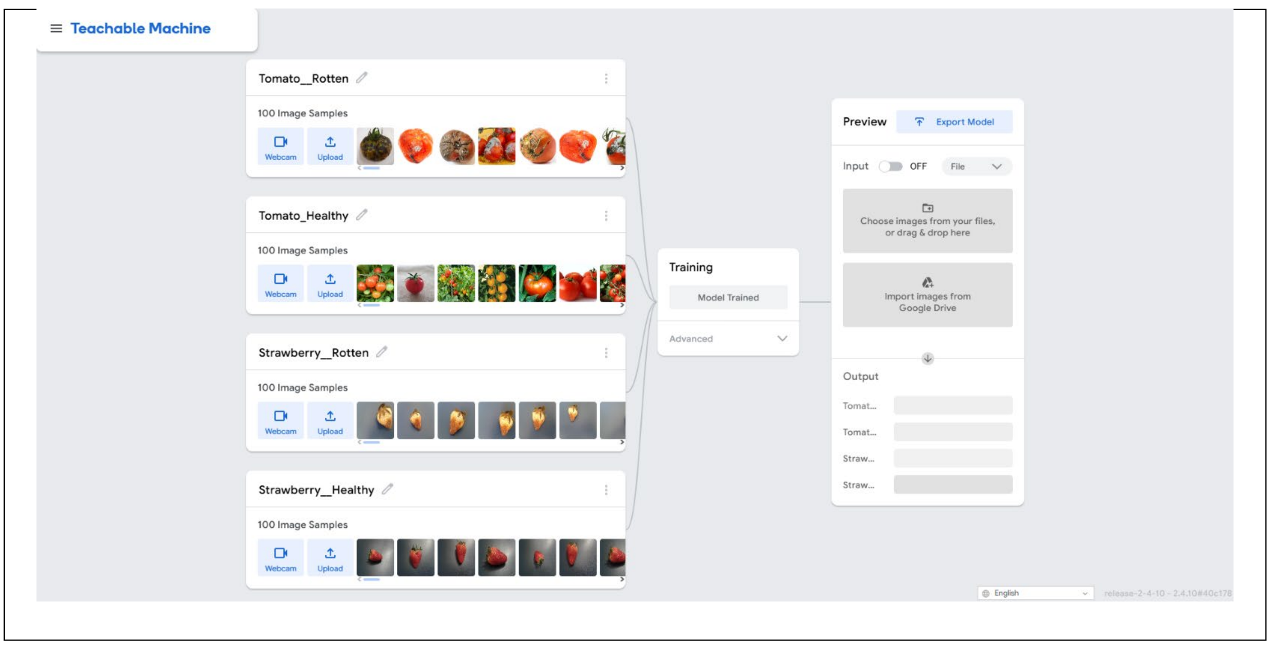
Dataset of all fruit and vegetable disease retrieved from Kaggle

3. Data Processing

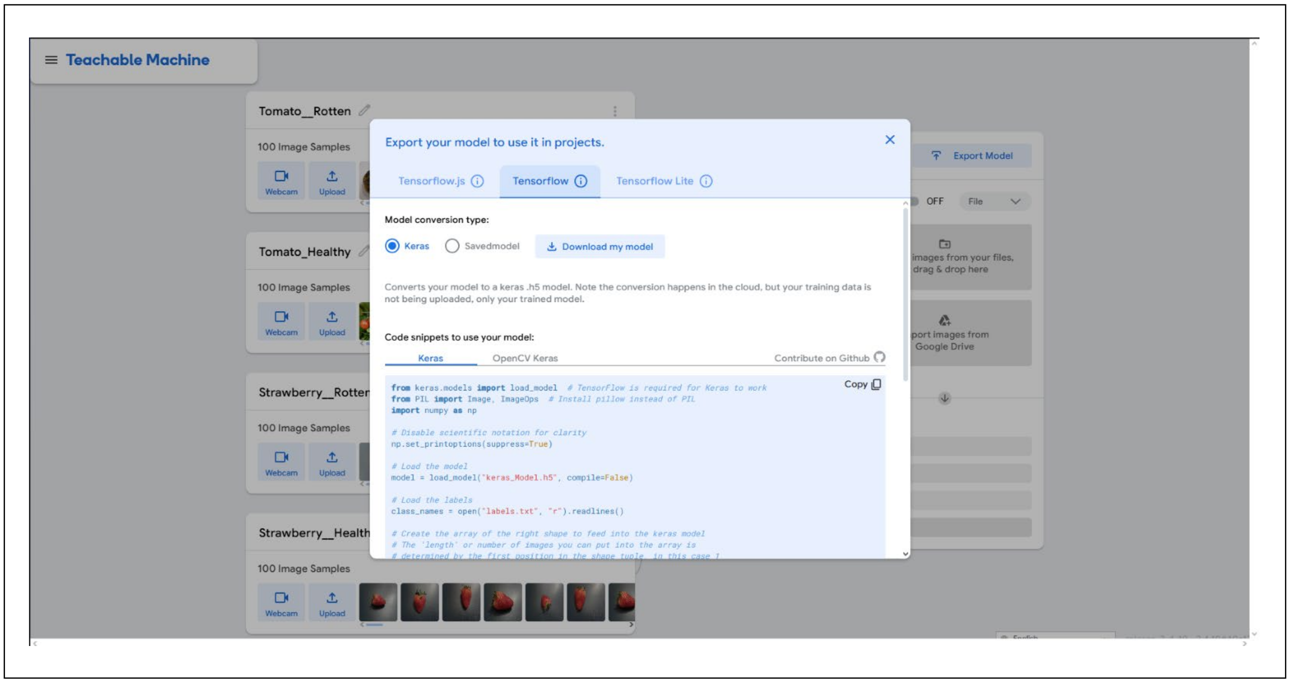


Using Teachable Machine to train the model to identify the fruit

4. Model Building

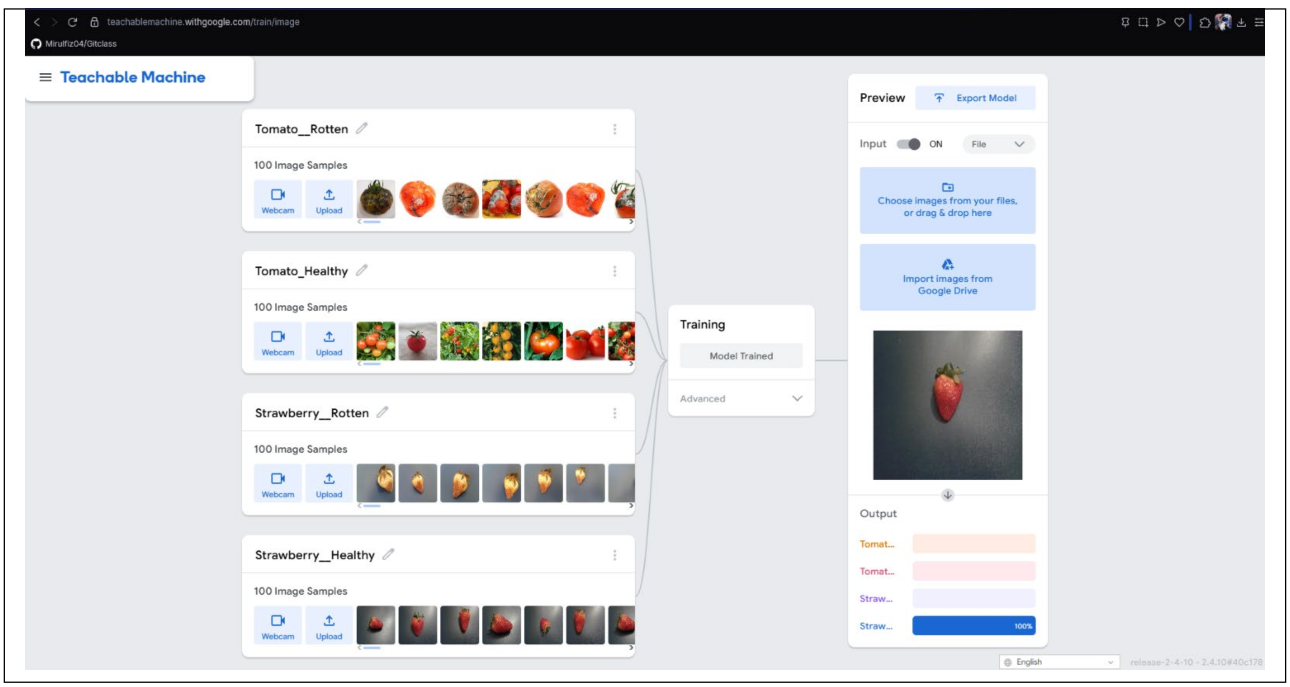


5. Training and Validation



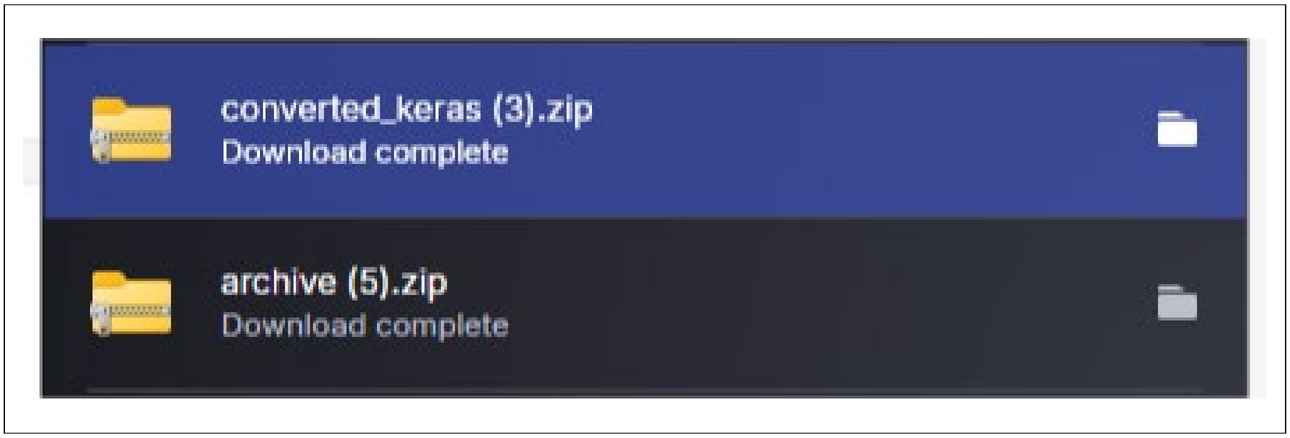
Exporting our trained model into code snippets to implement it.

6. Testing

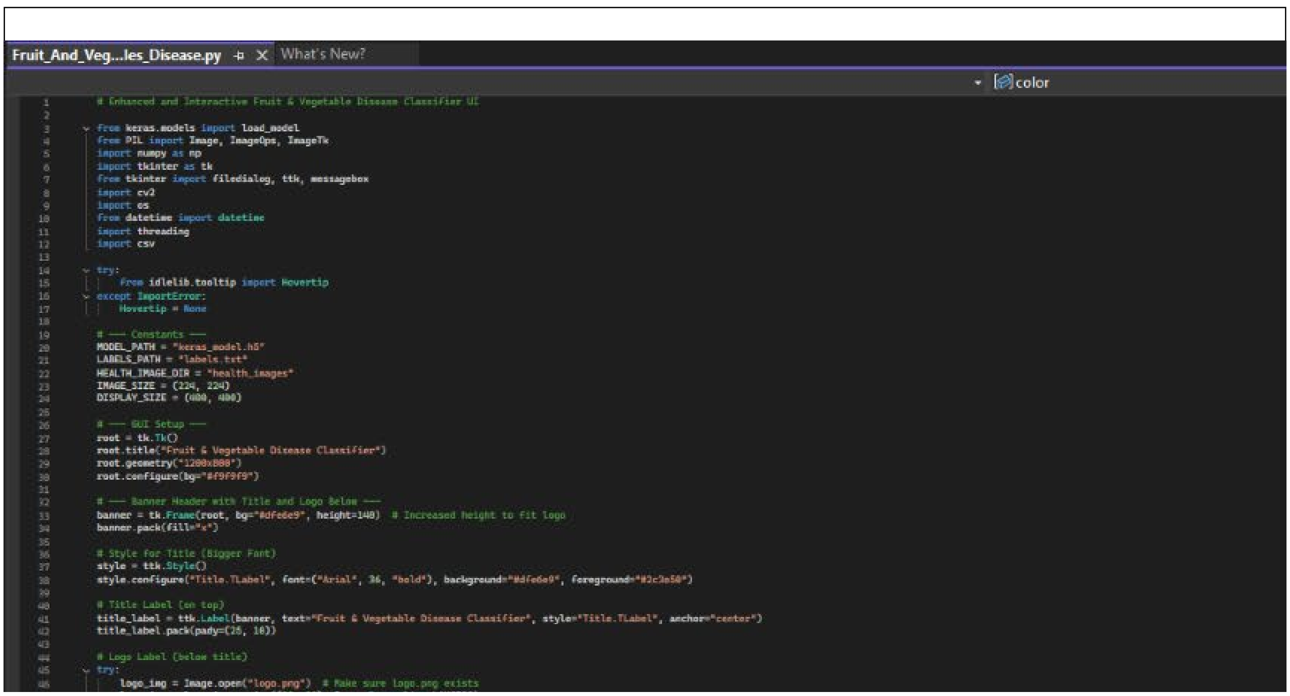


Using Teachable Machine to train the model to identify the cattle breeds

7. Deployment



Download Model that create by Teachable Machine



Implement model and use code given by Teachable Machine to python development in Visual Studio

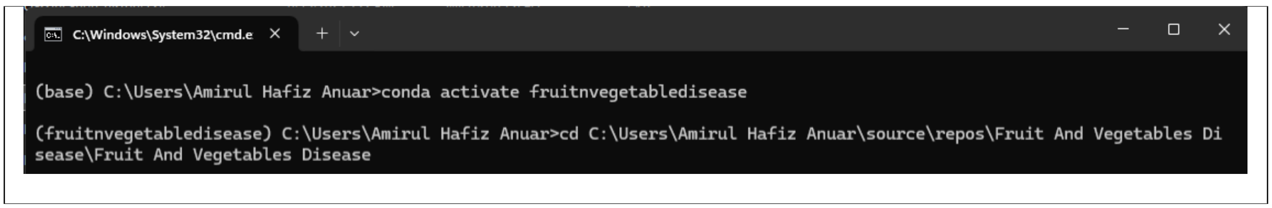
Benefits

- Correctly identifying spoiled or diseased produce.
- A better assurance of food safety and quality.
- A reduction of food waste through the early identification of rotten and diseased products.
- Time savings for farmers and retailers.
- Scalability for incorporation into intelligent agriculture systems.

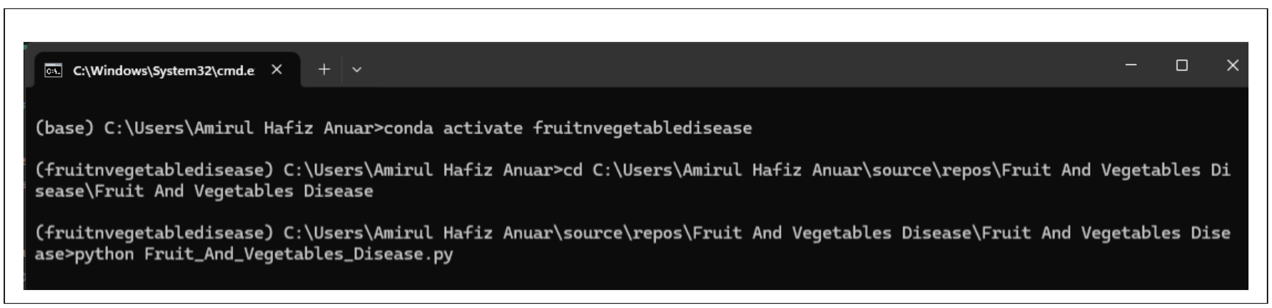
Part D: User Manual

- **Open anaconda navigator and run terminal base**

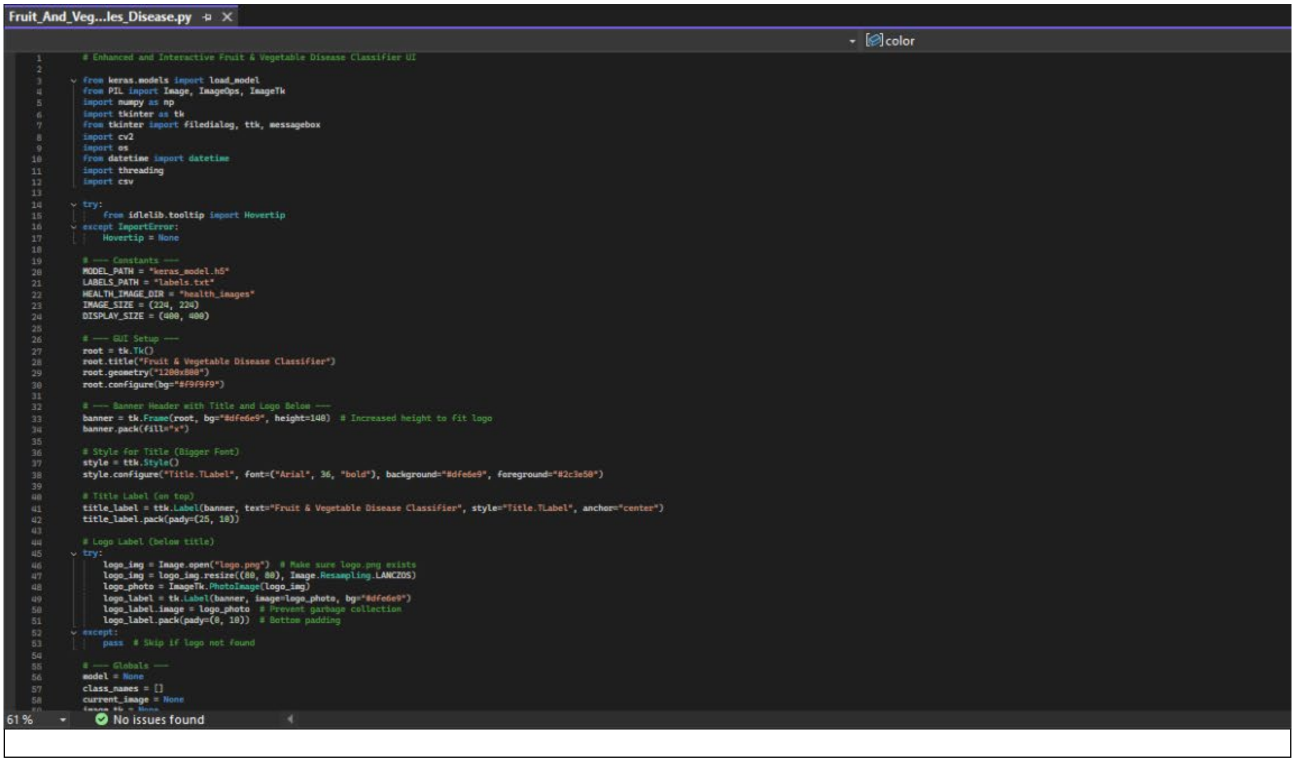
Activate the new environment



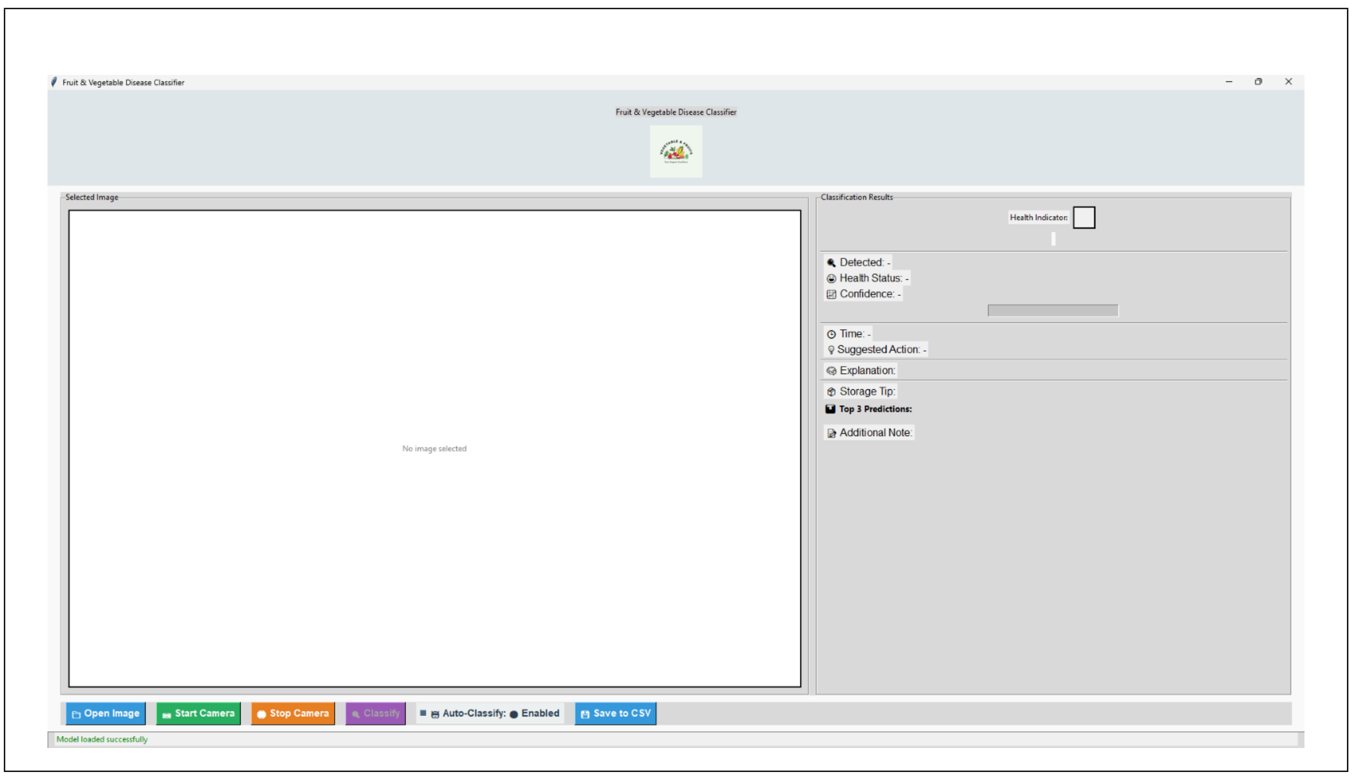
Go to folder location



Run the program



Source Code By Using Visual Studio Code

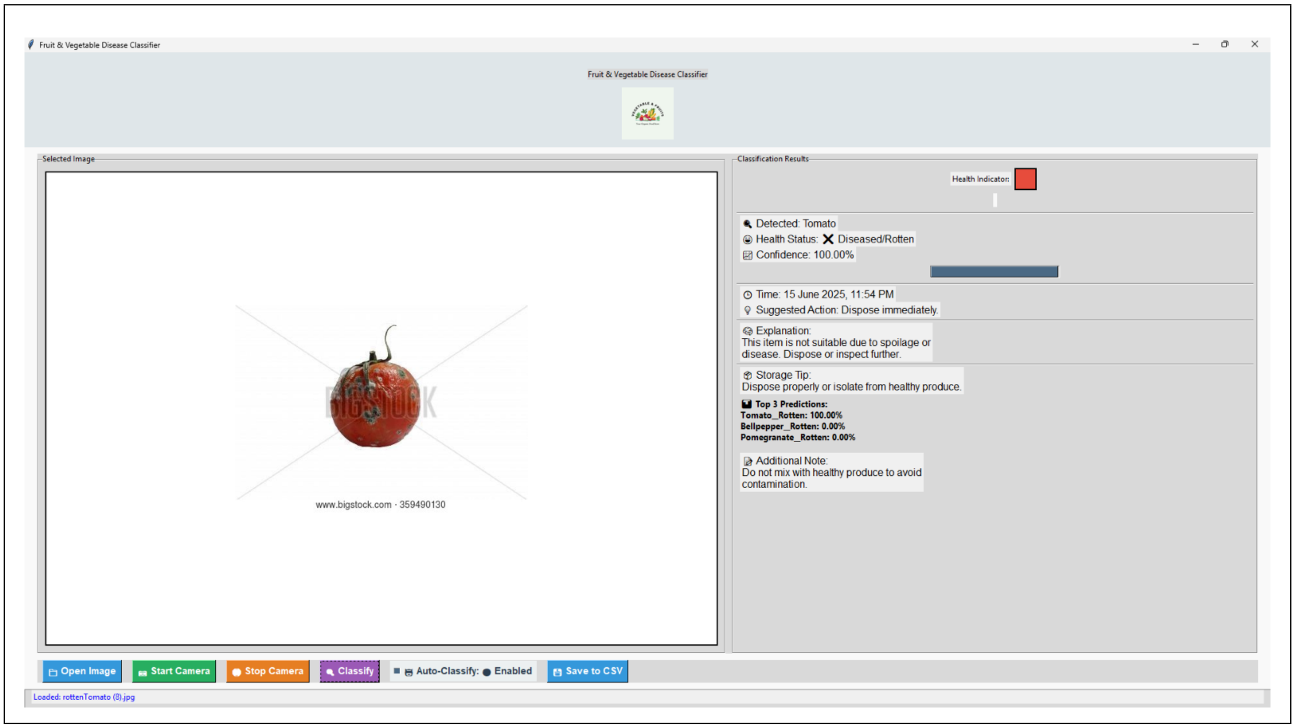


Open the System

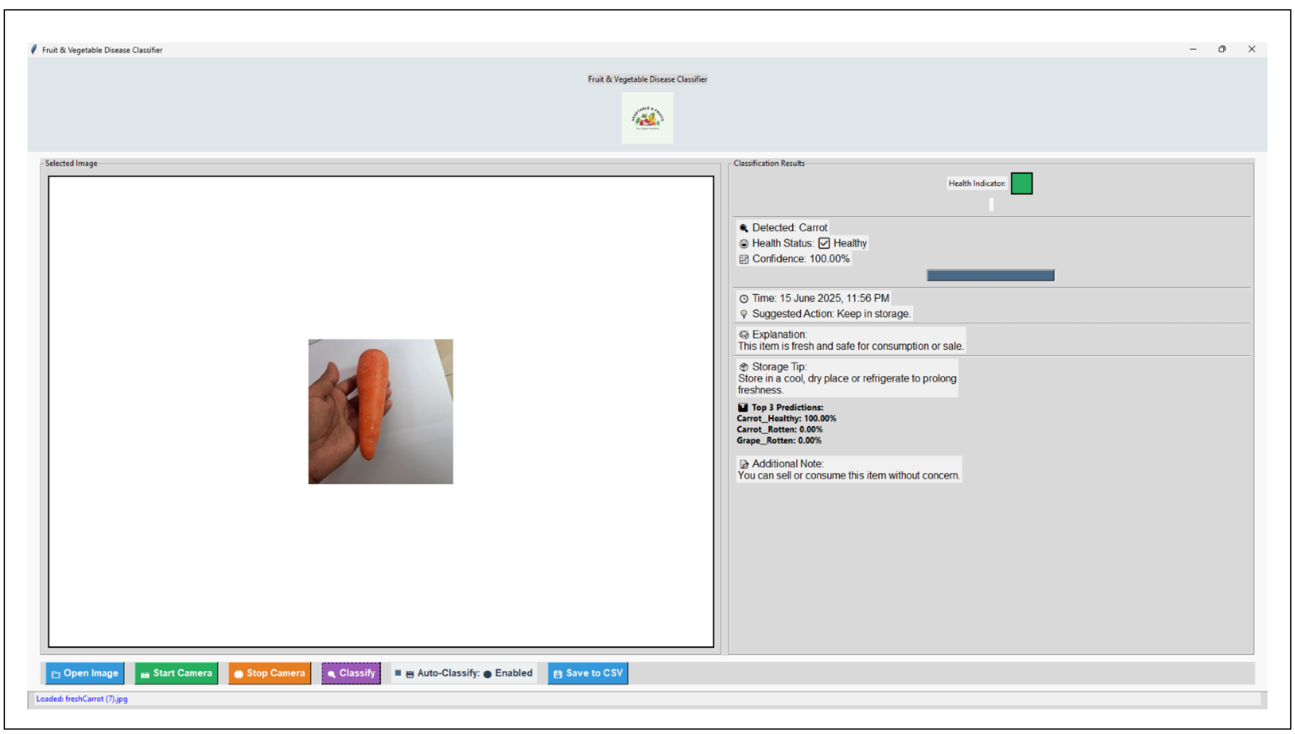
Part E: Testing Results

The following figures illustrate different classification outcomes produced by the system, including successful detection of healthy and rotten fruits, as well as a case of unidentifiable input:

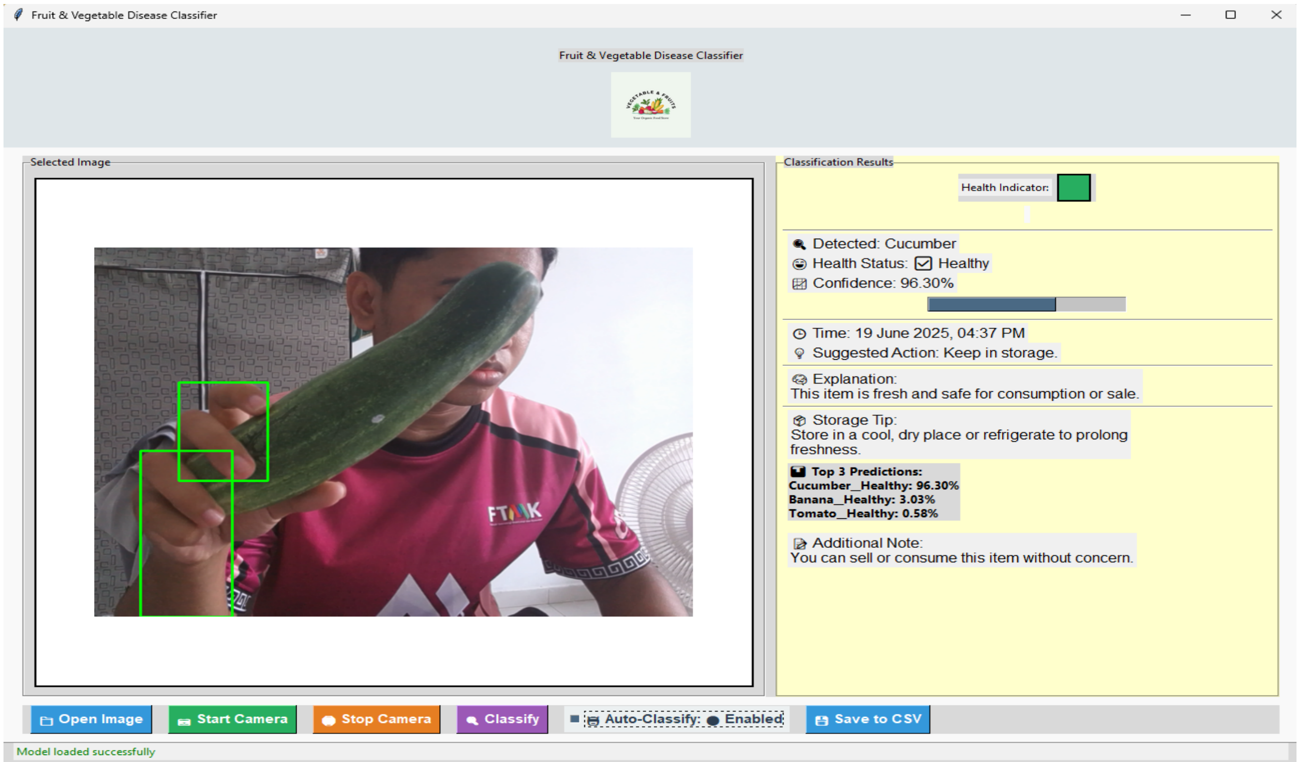
UI Screenshot



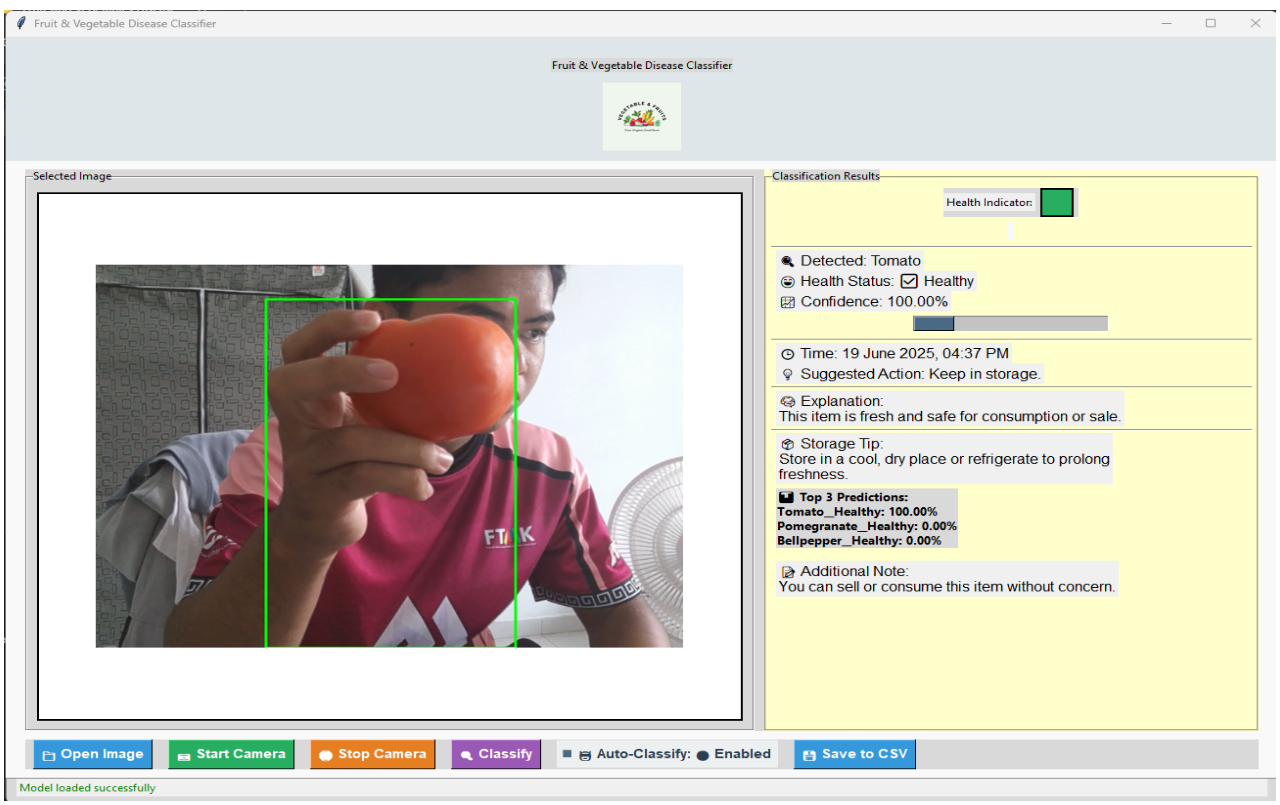
Classification of Rotten Fruit



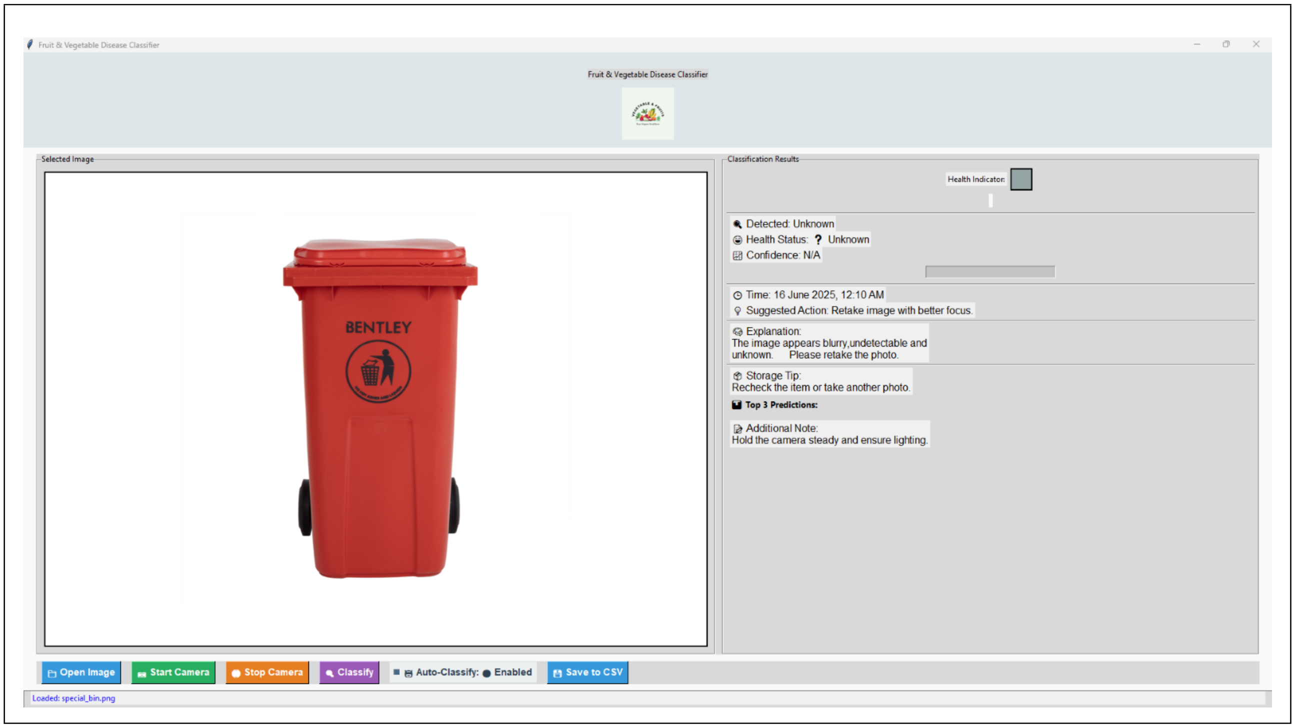
Classification of Healthy Fruit



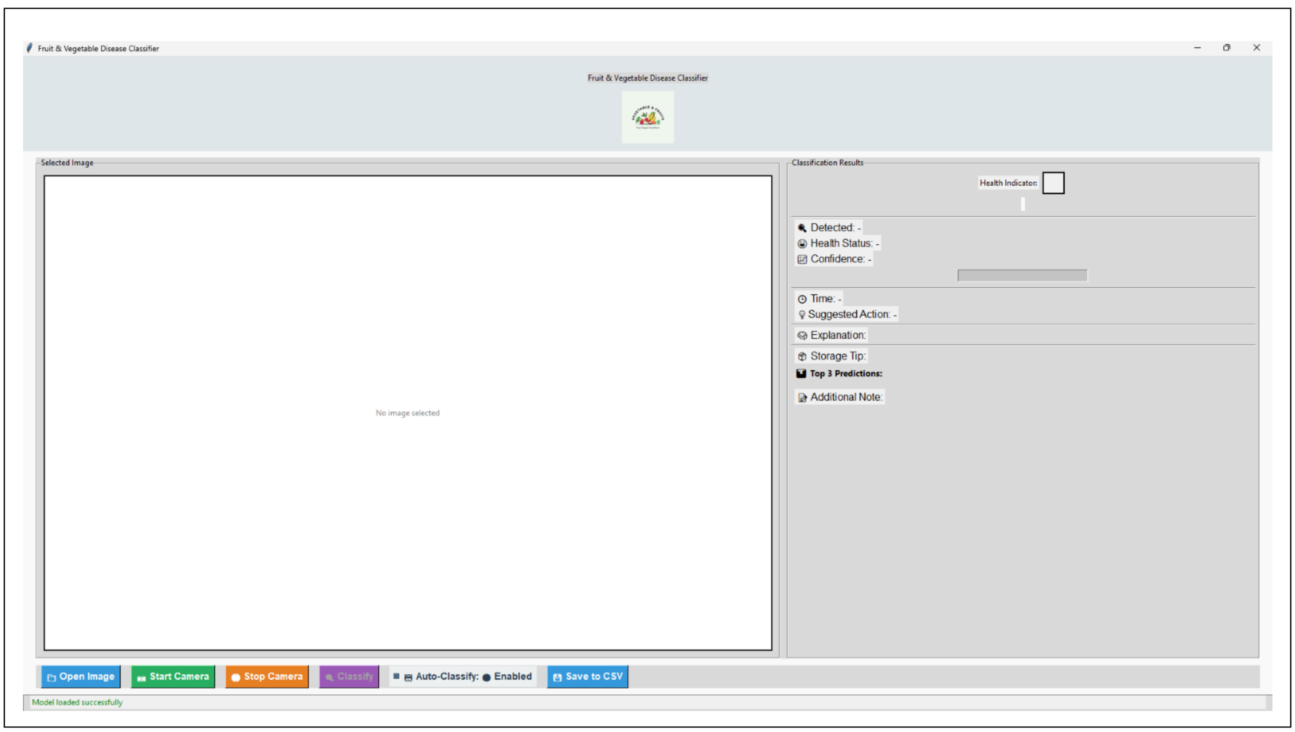
Detect Healthy Cucumber Using Camera



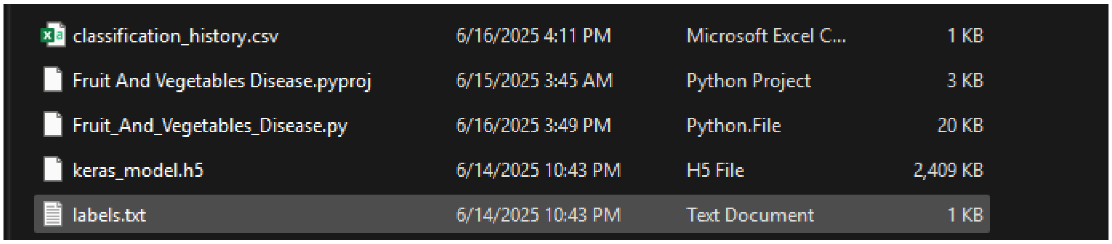
Detect Healthy Tomato Using Camera

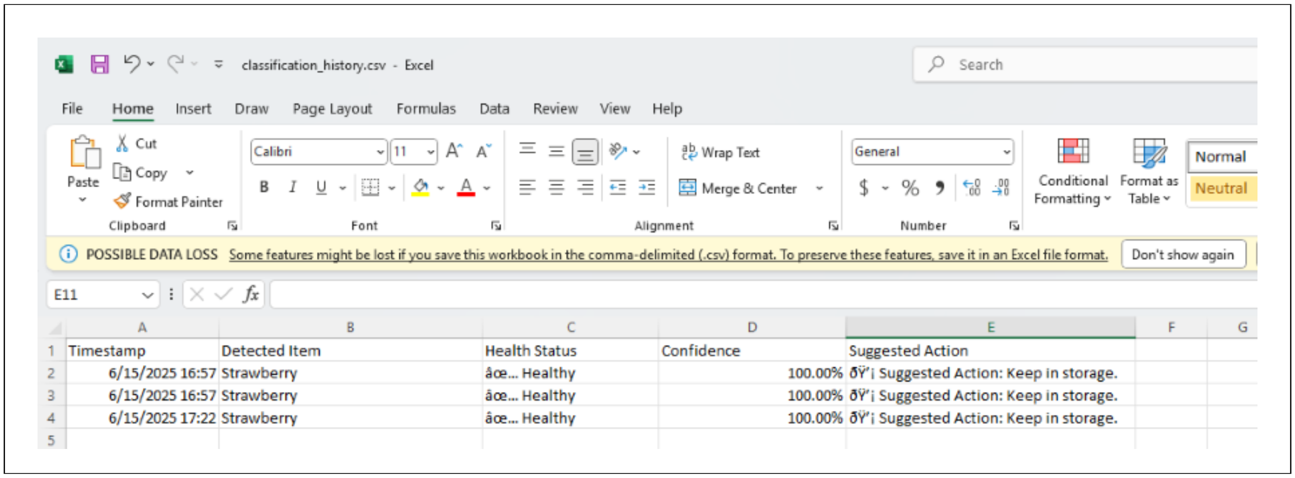


Detect Unknown Object



Main System Interface





CSV file saved

Part F: Conclusion

The newly established intelligent system was proposed for the identification and classification of healthy fruits and vegetables that are rotten using a CNN-based approach. It provides a benefit in terms of reducing the inefficiency of manual inspection in disease identification since it offers high accuracy in disease detection. In essence, the system ultimately serves various stakeholders in agriculture, food safety, and retail by reducing food loss, improving quality, and ultimately improving operational efficiency. Further to the system developments that were reported in this thesis, if taken further, this system may be extended to mobile technology in real-time applications and incorporated into smart farming systems.