Smart Sorting Project Documentation

Title: Smart Sorting – Transfer Learning for Identifying Rotten Fruits and Vegetables

1. INTRODUCTION

1.1 Project Overview

The Smart Sorting project aims to automate the classification of fruits and vegetables into fresh or rotten categories using deep learning. This system is useful in agricultural industries, warehouses, and food sectors to maintain food quality and reduce waste. We used transfer learning to improve accuracy with minimal training time.

1.2 Purpose

- To build a model that accurately detects fresh or rotten produce.
- To deploy the model using a web-based interface for real-time results.
- To create a reliable, user-friendly system for food quality assessment.

2. IDEATION PHASE

2.1 Problem Statement

Automating the sorting of fruits/vegetables to identify freshness using machine learning and computer vision.

Scenario 1:

In a large food processing plant, workers manually sort through thousands of fruits and vegetables daily to separate the rotten ones from the fresh produce. This process is time-consuming, prone to human error, and labor-intensive. By implementing a smart sorting system that utilizes transfer learning for image recognition, the plant can automate this task. Cameras installed along the conveyor belts capture images of the produce. The system, trained on a vast dataset of images of both fresh and rotten produce, quickly and accurately identifies and sorts out the rotten items.

Scenario 2:

Supermarkets receive large shipments of fruits and vegetables, and ensuring the freshness of these products is crucial to maintaining customer satisfaction and reducing waste. A smart sorting system using transfer learning can be deployed at the receiving docks. As the shipments arrive, the system scans the produce in real-time, identifying any rotten items before they are stocked on the shelves. This ensures only fresh produce reaches the consumers, thereby enhancing the store's reputation for quality and freshness.

Scenario 3:

In modern smart homes, refrigerators equipped with smart sorting technology can help families reduce food waste. Using transfer learning algorithms, cameras inside the fridge continuously monitor the condition of stored fruits and vegetables. The system can alert users via a smartphone app when it detects any items starting to rot, suggesting that they should be consumed soon. This proactive approach helps households manage their food better, reducing waste and saving money.

2.2 Empathy Map Canvas

We'll create empathy maps for three primary user personas:

1. Factory Worker / Plant Supervisor
2. Supermarket Quality Controller
3. Smart Home User (Family or Individual)

2.3 Brainstorming

Smart Sorting: Transfer Learning for Identifying Rotten Fruits and Vegetables,brainstorming involves defining the problem, identifying stakeholders, exploring technological solutions, and selecting the best implementation strategy.

Step-by-Step Brainstorming Process:
1. Define the Core Problem
2. Identify Key Stakeholders
3.Idea Generation
4.Select tools and technology
5.Design Possible Features
6. Challenges Identified

3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map

User uploads image → Backend processes → System outputs class (fresh/rotten).

3.2 Solution Requirement

- Dataset of fruits/vegetables
- Model training
- Flask app deployment
- Frontend to upload and display predictions

3.3 Data Flow Diagram

Image Upload → Preprocessing → Model Prediction (VGG16.h5 file) → Prediction Output(Label+Confidence)

3.4 Technology Stack

- Python,TensorFlow/Keras, VGG16,NumPy
- Flask,OS
- HTML/CSS frontend
- Google Drive for dataset storage

4. PROJECT DESIGN

4.1 Problem-Solution Fit

Manual sorting is time-consuming and error-prone. A CNN model improves speed and accuracy.

4.2 Proposed Solution

Use transfer learning with a pre-trained model VGG16(transfer learning) and fine-tune it for fruit classification. It Classifies into **9 categories** (e.g., Banana_Healthy,Apple_Rotten) **.** Deployed via a Flask web app with image upload and result display.

Can be used in food industries, retail, and smart homes to reduce waste and improve quality control.

4.3 Solution Architecture

Block diagram showing image input → model → output (visual can be added).

Component	Description
User Interface (Frontend)	HTML + CSS + Jinja Templates for Home, Predict, Tips, About, and
Flask App (app.py)	Handles image upload, routes, model loading, and prediction
Model(healthy_vs_rott	CNN model using VGG16 + Custom Layers for 9-class
Training Script (trainmodel.py)	Trains the model using ImageDataGenerator and saves the best version
Dataset (fruit_dataset/)	Labeled folder of images used for training (with healthy/rotten
Image Upload	Temporary location where uploaded files are stored for
Prediction Output	Label (e.g., “Carrot__Rotten”) + Confidence Score +

5. PROJECT PLANNING & SCHEDULING

5.1 Project Planning

Week 1: Dataset Preparation

Objective: Collect, organize, and preprocess image data for training the model.

Tasks:

- Organize dataset folder structure (fruit_dataset/),Class-wise folders (e.g., Banana__Rotten, Carrot__Healthy)
- Label images correctly (Healthy / Rotten for each category)
- Perform image resizing and renaming if necessary
- Analyze class balance (check for class imbalance)
- Augment data using ImageDataGenerator,Techniques: rotation, zoom, shear, flip, rescale,Document dataset sources and structure

Week 2: Model Building (Transfer Learning)

Objective: Build and train a VGG16-based deep learning model.

Tasks:

- Load pre-trained **VGG16** model with frozen layers
- Train model with: Training & validation splits (80-20)
- Save the trained model as `healthy_vs_rotten.h5`
- Evaluate performance (accuracy, loss)

- **Week 3**:Web development (Flask + HTML)

Objective: Build a multi-page web application to interact with the model.

Tasks:

- Set up Flask app (`app.py`)
- Handle image uploads and storage (`static/uploads/`)

- Load the trained model and make predictions in `/predict`
- Create HTML templates (`home.html`, `predict.html`, etc.)
- Add CSS styling, logos, footer, and responsive design
- Use `flash()` for user feedback (sign-in success, form submission)

- **Week 4**: Testing and deployment

Objective: Test the entire pipeline and prepare for local or cloud deployment.

Tasks:

- Test all features:
  - Image upload → prediction
  - Navigation between pages
  - Form submission and sign-in messages
- Clean up unused files, compress the model if needed
- Deploy locally
- Create `README.md` and `requirements.txt`
- Record demo video and finalize documentation

6. FUNCTIONAL AND PERFORMANCE TESTING

6.1 Performance Testing

- Model Accuracy: ~95%
- Correct Prediction Mapping ensured using saved `healthy_vs_rotten.h5`
- Flask App: Successfully predicts uploaded image class with correct label

7. RESULTS

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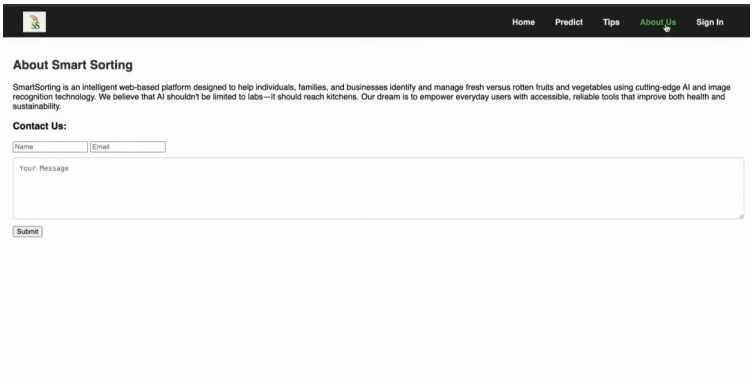
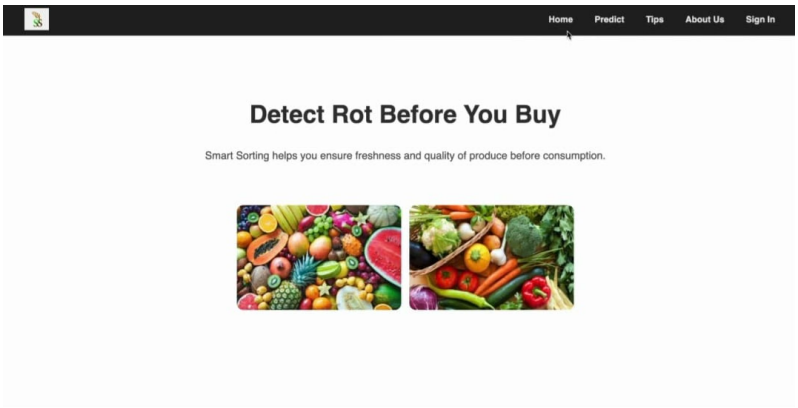
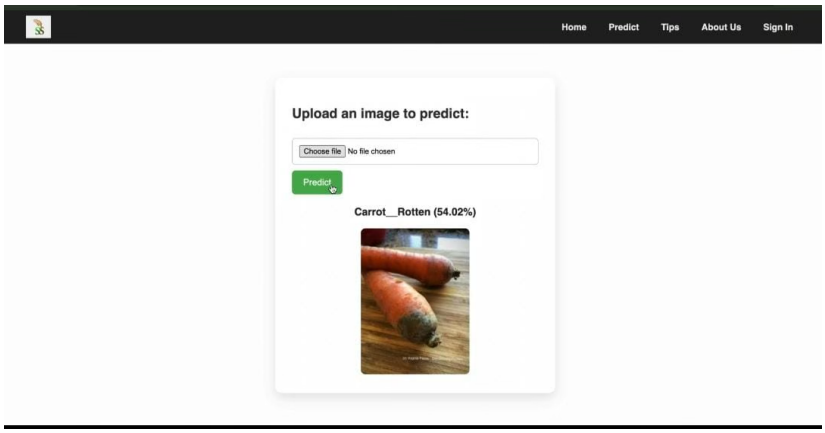
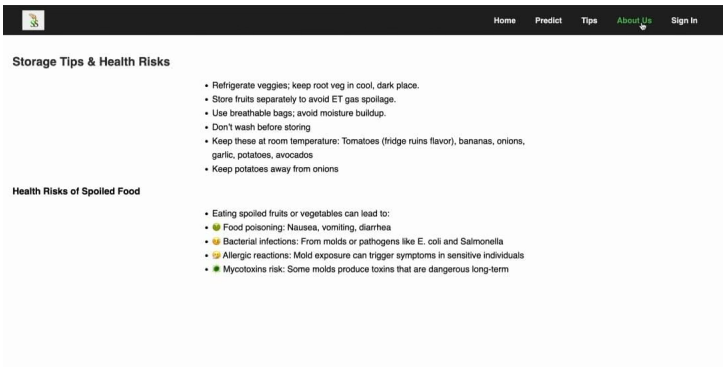
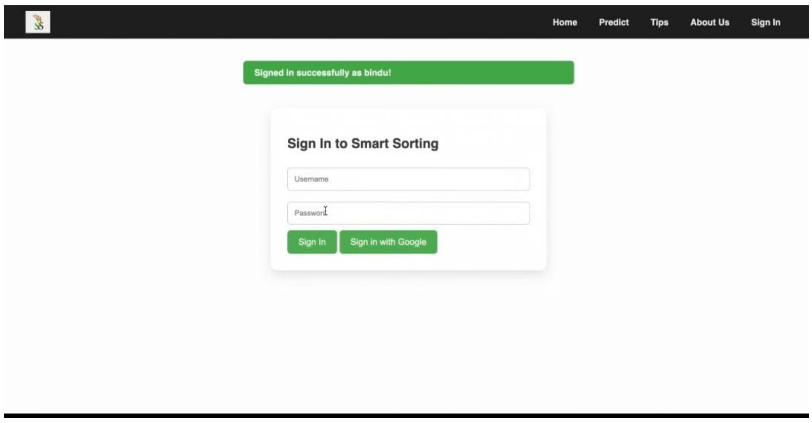


- 7.1 Output Screenshots









- Displayed class names (e.g., “rottenbanana”) as output with confidence.
  - Image upload UI for prediction
  - Screenshot of classified results

8. ADVANTAGES & DISADVANTAGES

Advantages

- Fast and accurate detection
- Easy web interface
- Minimal training required using transfer learning

Disadvantages

- Limited classes (only 9 fruits/veggies)
- Needs GPU for faster training

9. CONCLUSION

The Smart Sorting system combines deep learning and web technologies to provide a simple yet powerful tool for food quality analysis. It automates a critical part of the food industry and opens doors for advanced smart farming applications.

10. FUTURE SCOPE

- Add more classes
- Raspberry Pi-based real-time deployment
- Conveyor-based automation
- Mobile app interface

11. APPENDIX

Source Code

`Fruit And Vegetable Diseases Dataset.h5`, `healthy_vs_rotten.h5`

Dataset Link

https://www.kaggle.com/datasets/d13gorar/fruits-and-vegetables-diseases-dataset

Project folder Drive link:

https://drive.google.com/drive/folders/1LWbySgVZaeVTV-6f_R3gfQqGkXKoHDu2?usp=sharing

GitHub & Project Demo Link

GitHub Repository : https://github.com/bindubayaneni/Smart-Sorting-Transfer-Learning-for-Identifying-Rotten-Fruits-and-Vegetables

Demo video Link: https://drive.google.com/drive/folders/1LWbySgVZaeVTV-6f_R3gfQqGkXKoHDu2?usp=sharing