Fruit Defect Detection

Submitted in partial fulfillment of the requirements of the degree of

BACHELOR OF COMPUTER ENGINEERING

by

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(2023-2024)

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CERTIFICATE

This is to certify that the Mini Project 2A entitled **“Fruit Defect Detection”** is a bonafide work of **“Jarjish Siddibapa (22202003), Suraj Yadav (21102120), Tejaswini Todkar (21102102), Shivam Thorat(22202013)”** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of **Bachelor of Engineering** in **Computer Engineering.**

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Project Report Approval for Mini Project-2A

This project report entitled "**Fruit Defect Detection**" by ***Jarjish Siddibapa, Suraj Yadav, Tejaswini Todkar , Shivam Thorat*** is approved for the partial fulfillment of the degree of ***Bachelor of Engineering*** in ***Computer Engineering***, ***2023-24***.

Examiner Name	Signature
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2.____________________	_______________

Date:

Place: A P Shah Institute Of Technology, Thane

Declaration

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

The continuous advancements in machine learning have brought about significant progress in agricultural tasks, particularly in the domain of fruit detection and automatic harvesting. Deep learning, known for its proficiency in extracting complex features from fruit images, is widely employed in this context. Convolutional neural networks, in particular, have shown remarkable capabilities, achieving accuracy and speed levels comparable to human performance in some fruit detection and automatic harvesting applications. This paper offers an extensive review of fruit detection and recognition based on deep learning, spanning from 2018 to the present day. The paper focuses on the current challenges affecting the performance of fruit detection systems for automatic harvesting, including the limited availability of high-quality fruit datasets, the detection of small fruit targets, dealing with occluded and densely packed fruit scenarios, and the recognition of fruits of various sizes and species. Moreover, the paper addresses the need for lightweight fruit detection models. In response to these challenges, the paper proposes practical solutions and outlines potential future directions for development. It underscores the importance of prioritizing research efforts aimed at overcoming these challenges while enhancing the accuracy, speed, resilience, and adaptability of fruit vision detection systems, all while minimizing complexity and cost. The intention behind this paper is to serve as a valuable reference for future research in the realm of fruit detection and recognition based on deep learning for automatic harvesting.

Keywords: computer vision; deep learning; fruit detection; fruit recognition; automatic harvesting; current challenge; development trend; research review

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Chapter 1
Introduction

The Fruit Defect Detection System is a groundbreaking project redefining fruit quality assessment, with a primary focus on apples, oranges, and bananas. Leveraging advanced technologies like machine learning, deep learning, computer vision, and real-time data analysis, guided by the user-centric React framework, this project responds to the limitations of traditional fruit quality control methods. These methods are labor-intensive, subjective, and compromise food safety and resource efficiency. The central objective is to introduce an automated system for swiftly and accurately identifying defects in the target fruits. By integrating supervised machine learning with Convolutional Neural Networks (CNN), the system strives for a defect detection accuracy of at least 95% and acknowledges the importance of assessing fruit ripeness, a critical factor influencing taste and usability. Real-time analysis capabilities facilitated by the MobileNetV2 architecture empower users in various settings, from retail to homes, to make informed decisions about fruit quality.

User experience is paramount, with the project's user-friendly React interface ensuring accessibility. Swift image capture and real-time processing enable users to easily capture fruit images and access detailed defect information and ripeness assessments. The system's camera swiftly captures images, which are processed in seconds to provide immediate results, revolutionizing quality control and user experiences.

The unwavering commitment to accuracy and performance is reflected in stringent data privacy measures. The project complies with data protection regulations and intellectual property rights, embodying the fusion of tradition with innovation. It strives to enhance food safety, reduce waste, and elevate consumer experiences. This report explores the project's objectives, implementation, problem statement, and scope, highlighting its transformative potential in the agriculture and food sectors.

Chapter 2

Literature Survey

An extensive review of the literature on the topic of fruit detection utilizing machine learning and deep learning techniques reveals a steadily expanding body of research that aims to enhance automated fruit detection and recognition. Numerous research papers and studies have made significant contributions to this field, often concentrating on diverse facets of fruit detection and employing a range of machine learning and deep learning models. Here's a synopsis of some noteworthy research papers and their key findings in this domain:

1. **"Comprehensive Review of Fruit Detection and Recognition" by Khan, M. A., et al. (2020):**
   - This paper presents a comprehensive evaluation of fruit detection and recognition methods available up to the year 2018.
   - It encompasses traditional image processing techniques, machine learning algorithms, and the emerging use of deep learning, particularly convolutional neural networks (CNNs).
   - The research underscores the critical role of precise fruit detection in agriculture for yield estimation and quality control.

2. **"Deep Learning for Orchard Fruit Detection" by Bargoti, S., and Underwood, J. (2019):**
   - This study concentrates on employing deep learning, specifically CNNs, for detecting fruits in orchards.
   - It introduces a real-time fruit detection system with the potential to automate the harvesting process.
   - The authors address challenges associated with obstructions, varying lighting conditions, and diverse fruit types.

3. **"Exploration of Deep Learning in Machine Vision Systems for Automated Fruit Recognition" by Rahnemoonfar, M., and Sheppard, C. (2019):**
   - This paper offers insights into the applications of deep learning in fruit recognition.
   - It discusses the significance of substantial datasets and the utilization of pre-trained models.

4. “**Deep Fruit Classification with the Fruit 360 Dataset” by Horea Muresan et al. (2018):**
   - This research introduces the Fruit 360 dataset, a vast collection of fruit images comprising over 90,000 labeled samples from 131 different fruit categories.
   - It places an emphasis on deep learning-based fruit classification and illustrates the potential for building robust models using extensive datasets.

5. **“Accurate Fruit Detection and Counting in Orchards with Fast R-CNN” by Liu, S., et al. (2018):**
   - This paper tackles the detection and counting of fruits in orchards using the Fast R-CNN deep learning model.
   - It underscores the importance of achieving both speed and accuracy, particularly in practical applications like precision agriculture.

6. “**Leveraging Deep Learning Techniques for Fruit Detection” by Wagh, A., et al. (2019):**
   - This research paper explores the implementation of deep learning techniques, including CNNs, for detecting fruits in images.
   - It delves into the role of data augmentation and various pre-processing steps to enhance detection accuracy.

7. **“Real-time Fruit Detection and Localization for Robotic Harvesting” by Sa, I., et al. (2021):**
   - The paper delves into real-time fruit detection and localization through deep learning for applications involving robotic harvesting.
   - It highlights the necessity of addressing challenges such as variations in fruit appearance and environmental conditions.

These research papers collectively signify the mounting interest and advancements in the realm of fruit detection using machine learning and deep learning. Researchers continue to make strides in improving the precision, speed, and resilience of fruit detection systems, rendering them increasingly invaluable for precision agriculture and automated harvesting applications

Research Paper	ANALYSIS
1 "Comprehensive Review of Fruit Detection and Recognition"	- Comprehensive review of fruit detection methods up to 2018. - Traditional image processing, machine learning, and deep learning (CNNs). - Emphasizes the importance of accurate fruit detection in agriculture..
2 "Deep Learning for Orchard Fruit Detection"	- Utilizes deep learning (CNNs) for orchard fruit detection. - Introduces a real-time fruit detection system for potential harvesting automation. - Addresses challenges such as obstructions, varying lighting, and fruit diversity
3 "Exploration of Deep Learning in Machine Vision Systems for automated fruit recognition"	- Discusses applications of deep learning in fruit recognition. Automated Fruit Recognition" - Highlights the significance of extensive datasets and pre-trained models. - Explores transfer learning for adapting models to different fruit varieties.
4. "Accurate Fruit Detection and Counting in Orchards with Fast R-CNN"	- Addresses fruit detection and counting in orchards using Fast R-CNN deep learning model. - Emphasizes speed and accuracy for practical applications, such as precision agriculture.
5. "Leveraging Deep Learning Techniques for Fruit Detection"	- Explores deep learning techniques, including CNNs, for fruit detection in images. - Investigates the role of data augmentation and preprocessing for improved detection accuracy

Chapter 3
Problem Statement, Objective & Scope

Problem Statement

To create a defect fruit detection web portal where farmers or brokers can detect a fruit with the help of uploading image , live prediction for large data and open camera to click image using technology JavaScript, AXIOS, JSON, Cors, HTTP, Python, Flask, Tailwind CSS, React, API CNN, MobileNetV2.

The agricultural and food industries grapple with a substantial challenge: the accurate assessment of fruit quality, with a primary focus on apples, oranges, and bananas. Traditional manual inspection methods are arduous, marked by subjectivity, and pose risks of subpar produce reaching consumers. The core issue addressed in this project is the inadequacy of conventional fruit quality control methods, characterized by labor-intensive processes and human subjectivity. The margin for error in identifying defects, such as bruises and discolorations, not only endangers food safety but also leads to economic losses.

The Fruit Defect Detection System project confronts this challenge with a precise and efficient solution, striving to develop an automated system for swift and accurate defect identification in fruits. Grounded in supervised machine learning with Convolutional Neural Networks (CNN), the project aims to achieve a defect detection accuracy rate of at least 95%. Beyond defect identification, the system recognizes the critical importance of assessing fruit ripeness, a key factor influencing taste and usability.

At the project's core is a user-friendly interface built with the React framework, ensuring accessibility for users of various technical backgrounds. It enables easy fruit image capture, analysis initiation, and access to detailed defect and ripeness information. The system's swift image processing, facilitated by the MobileNetV2 architecture, provides instant results, transforming quality control and user experiences across different domains. Stringent data privacy measures protect user data and images, complying with data protection regulations and intellectual property rights. In summary, this problem statement underscores the need to harness technology to revolutionize longstanding agricultural and food industry challenges, enhancing food safety, reducing waste, and elevating consumer experiences.

Objective: -

The Fruit Defect Detection System project is driven by a set of comprehensive objectives that guide its mission to transform fruit quality assessments. These objectives are intricately designed to address critical challenges in the agricultural and food industries, making significant advancements in quality control and food safety. The following outlines the key objectives of the project:

- **Precise Defect Detection:** The primary goal of the project is to develop a machine learning system that can accurately and swiftly identify defects in apples, oranges, and bananas. These defects include common issues like bruises, blemishes, and discolorations. The project aims to achieve a defect detection accuracy of at least 95%. By accomplishing this, the project aims to contribute significantly to food safety by minimizing the risk of substandard produce reaching consumers.

- **Real-Time Ripeness Assessment:** In addition to defect detection, the project emphasizes the importance of assessing fruit ripeness. Ripeness is a critical factor that directly influences taste and usability. The project intends to implement a dedicated module for real-time ripeness assessment, considering factors such as color, texture, and firmness. This feature ensures that consumers receive fruits that align with their preferences, enhancing their overall satisfaction.

- **User-Friendly Interface:** The project prioritizes user accessibility by creating an intuitive user interface. Developed using React, this interface allows users with varying technical backgrounds to effortlessly capture images of fruits, initiate the analysis process, and view detailed defect and ripeness information in real-time. By making the system user-friendly, the project ensures that it is accessible to a wide range of users.

- **Swift Real-Time Analysis:** The project aims to enable swift real-time analysis using a camera. It sets a target of processing fruit images within seconds, ensuring that quality assessments are efficient and suitable for diverse settings. This real-time analysis can have applications in retail, distribution centers, and homes, where immediate results are critical.

- **Food Safety Enhancement:** By reducing the likelihood of substandard produce reaching consumers, the project contributes significantly to food safety. It aims to improve food safety standards and reduce health risks associated with the consumption of defective fruits.

- **Minimize Food Wastage:** Accurate quality assessments and real-time analysis contribute to better inventory management, minimizing food wastage. By reducing economic losses for both producers and consumers, the project supports sustainability and resource efficiency.

- **Improved Consumer Experiences:** Through real-time quality assessments, the project enhances consumer experiences. It empowers consumers to make informed purchasing decisions, ensuring that they acquire fruits that meet their preferences and needs, thus bolstering overall consumer satisfaction.

Scope: -

The scope of the Fruit Defect Detection System project is to develop an efficient solution for fruit quality assessment with a primary focus on apples, oranges, and bananas. The project seeks to address key aspects and objectives, while maintaining a streamlined scope:

- **Fruit Variety and Defect Coverage -** The project centers on defect detection in apples, oranges, and bananas. The system aims to accurately identify common issues like bruises, blemishes, and discolorations, ensuring comprehensive coverage. While these three fruits are the primary focus, the system's architecture remains adaptable for the inclusion of additional varieties.

- **Real-Time Inspection -** The project emphasizes real-time fruit quality analysis using an integrated camera. It prioritizes swift image capture and processing, providing results within seconds. This real-time analysis feature is designed to enhance quality control across various settings, including retail, distribution centers, and homes.

- **User-Friendly Interface -** The project features a user-friendly interface developed with React to ensure accessibility. The interface allows users to capture fruit images, initiate analysis, and view defect information and ripeness assessments. User-centric design remains a central element of the project's scope.

- **Accuracy and Performance Metrics -** The project commits to achieving high accuracy in defect detection, with an evaluation based on precision, recall, and F1 score. Performance metrics will be established to measure the system's efficiency in image processing and real-time results.

- **Scalability -** Opportunities for system scalability will be explored to handle increasing inspection volumes. The project anticipates potential growth and adoption, aligning with evolving industry demands.

- **Continuous Improvement -** A feedback loop for continuous system improvement is established. This includes incorporating new data, user feedback, and emerging technologies to enhance system performance, accuracy, and adaptability over time.

- **Ethical Considerations -** The project maintains the highest ethical standards, ensuring compliance with data privacy regulations and intellectual property rights in the handling of user data and information.

The streamlined scope encapsulates the project's commitment to innovative and efficient fruit quality assessments, contributing to food safety, waste reduction, and enhanced consumer experiences. It defines clear boundaries while allowing adaptability for future growth and continuous improvement.

Chapter 4

Proposed System Architecture

Description about Proposed System:

The Fruit Defect Detection System's system architecture integrates advanced technologies in a user-centric framework. The architecture comprises several key modules, ensuring seamless operation. It commences with the Data Collection and Labeling Module, responsible for assembling and labeling high-resolution fruit images. This module curates' datasets of defect-free and defective fruit samples for machine learning model training.

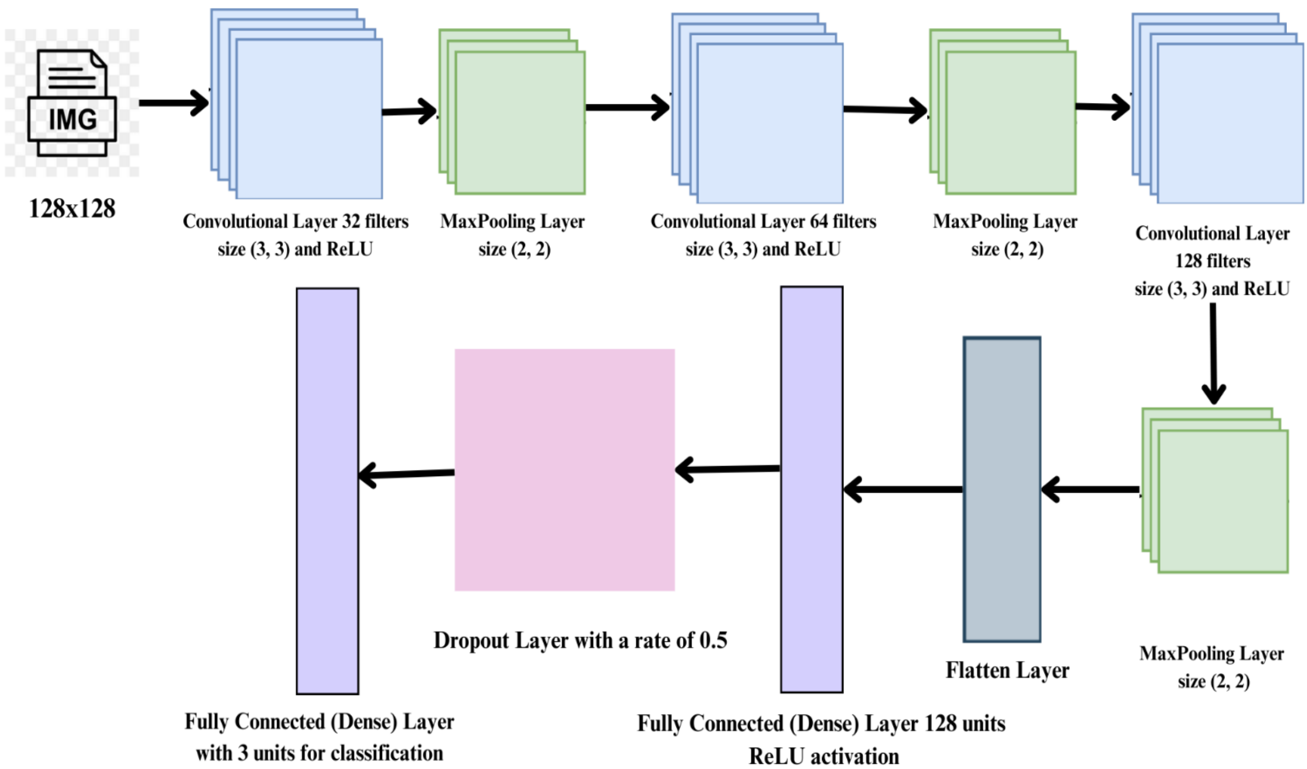
At its core, the Machine Learning and Deep Learning Module employs supervised machine learning with Convolutional Neural Networks (CNN) to facilitate defect detection. The MobileNetV2 Integration Module ensures real-time analysis, thanks to its lightweight neural network architecture. This module enables rapid image capture and processing, providing immediate results.

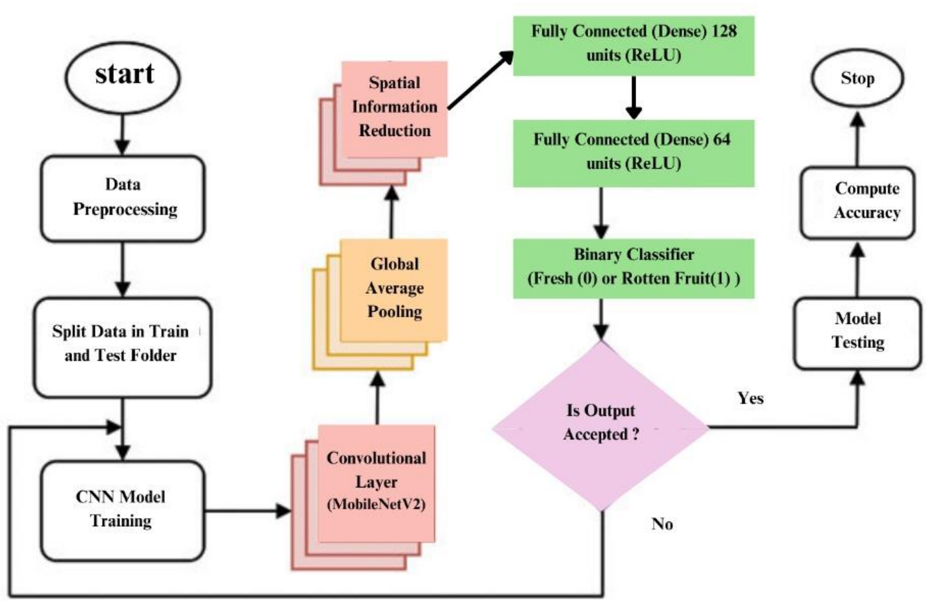
User interaction is paramount through the User Interface Module (React), designed for accessibility. It allows users to capture fruit images and access detailed defect and ripeness assessments in real time. The Real-Time Image Processing Module lies at the heart of this, ensuring swift defect detection and ripeness assessments.

The system's commitment to precision and performance is evident in the Accuracy and Performance Evaluation Module, which uses precision, recall, and F1 score assessments to gauge defect detection accuracy. Performance metrics measure image processing efficiency. The Data Privacy and Compliance Module safeguards user data and images, aligning with data protection regulations and intellectual property rights.

Designed for scalability and future adaptability, the system includes a Scalability and Future Adaptation Module, accommodating increased inspection volumes and seamless integration of enhancements. Ethical compliance is integral, ensuring the project respects data privacy and intellectual property rights. This comprehensive system architecture blends innovation and tradition, emphasizing food safety, waste reduction, and improved user experiences within the agriculture and food sectors.

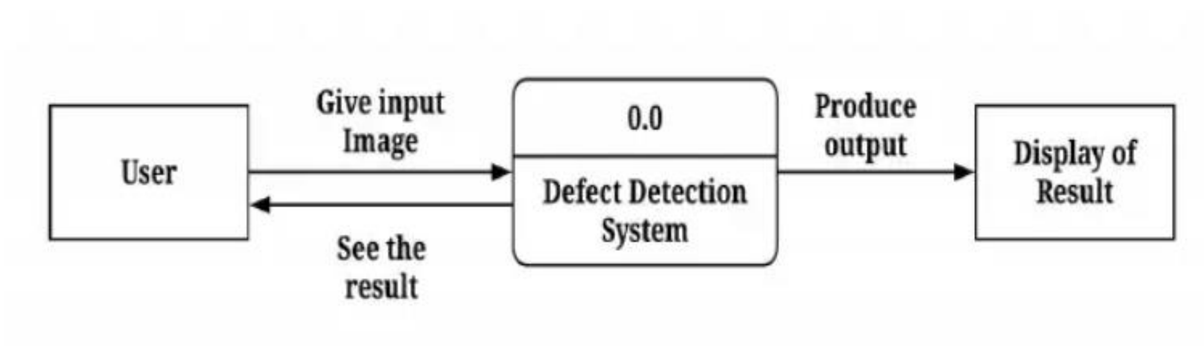
Architecture / Block Diagram:



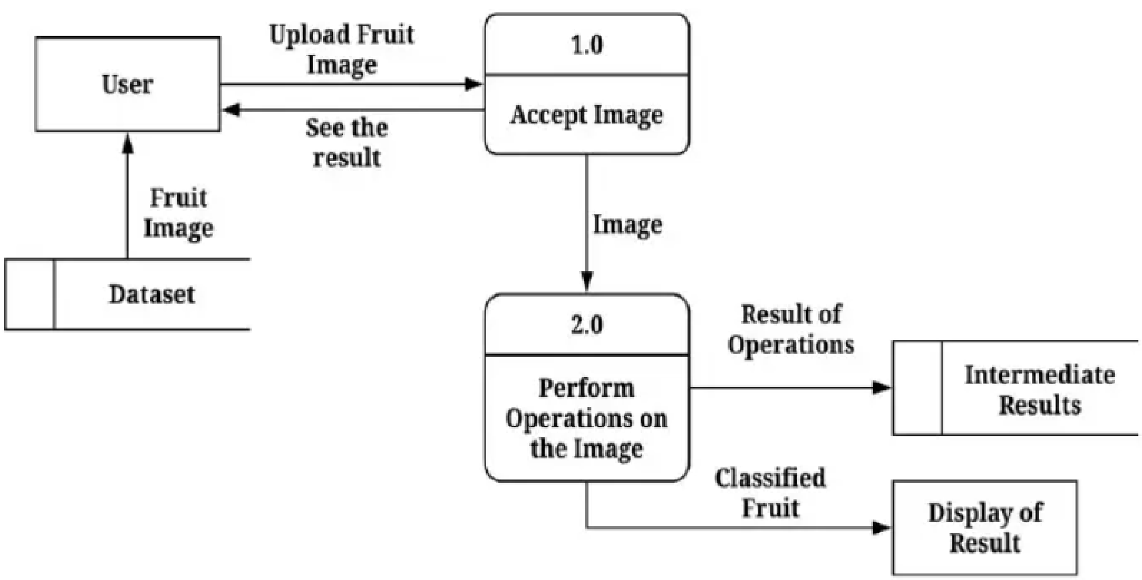


Data Flow Diagram (Level 0, Level 1 & Level 2):

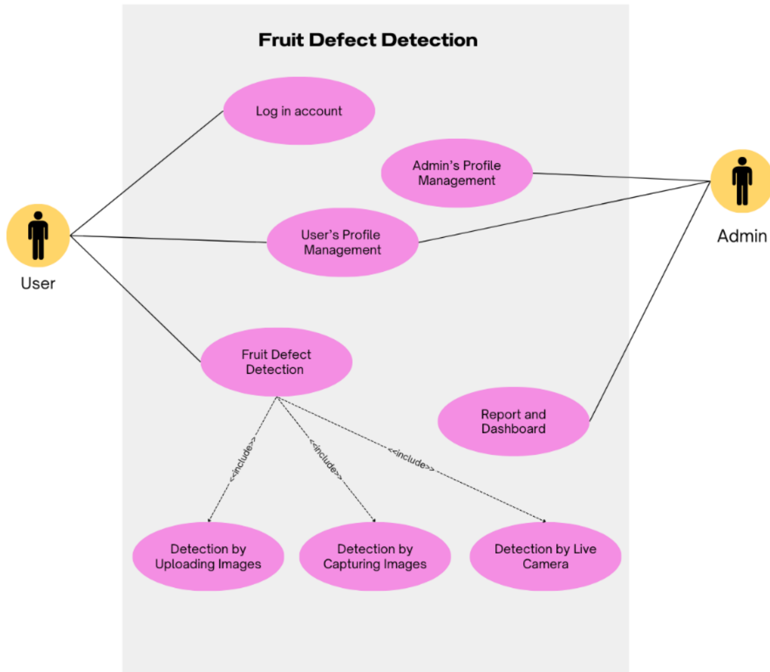
DFD Level – 0:



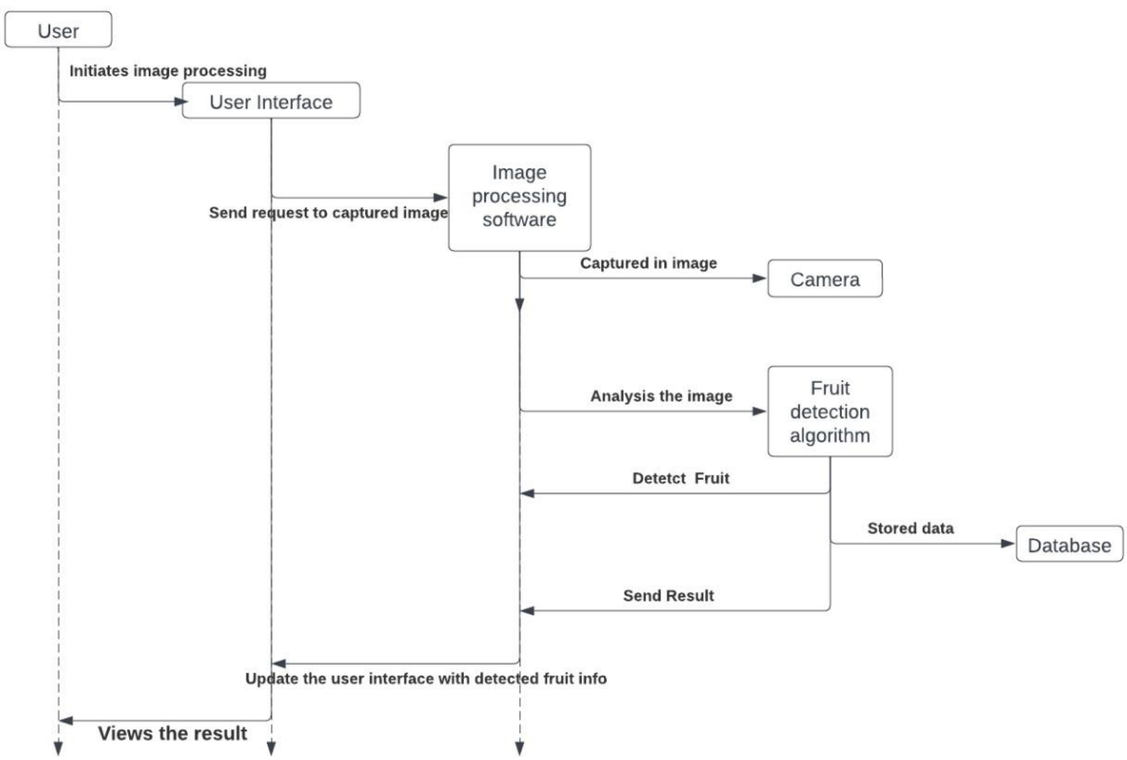
DFD Level – 1:



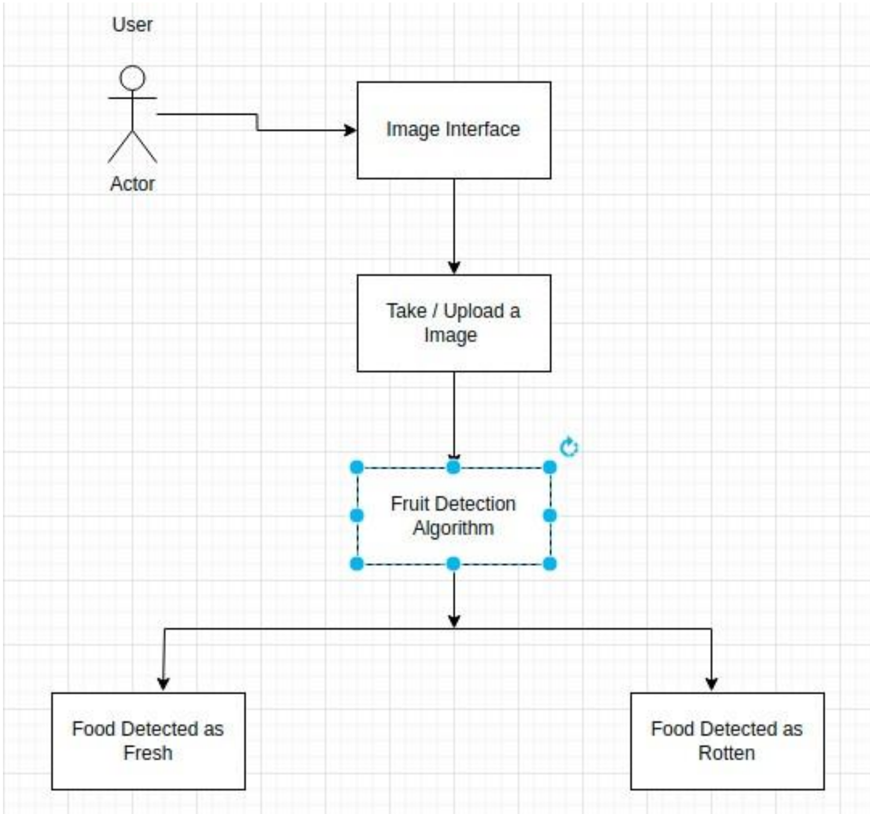
Use Case Diagram:



Sequence Diagram:



Activity Diagram:



Chapter 5

Project Planning

Chapter 6

Experimental Setup

- **<u>Software Requirements</u>**

1) Operating System Compatibility: Support for Windows, macOS, and Linux.
2) Programming Languages: Python and JavaScript.
3) Development Tools: IDEs (e.g., PyCharm), Git for version control.
4) Computer Vision Libraries: OpenCV, TensorFlow, or PyTorch.
5) Web Development: React for the user interface.

- **<u>Hardware Requirements</u>**

1) CPU: Multi-core processor for image processing and analysis.
2) GPU: Optional dedicated Graphics Processing Unit for accelerated deep learning tasks.
3) RAM: Minimum 8GB of RAM for efficient data handling.
4) STORAGE: Adequate storage space for image data and model files.
5) OS: Compatibility with Windows, macOS, and Linux.

Chapter 7

Implementation Details

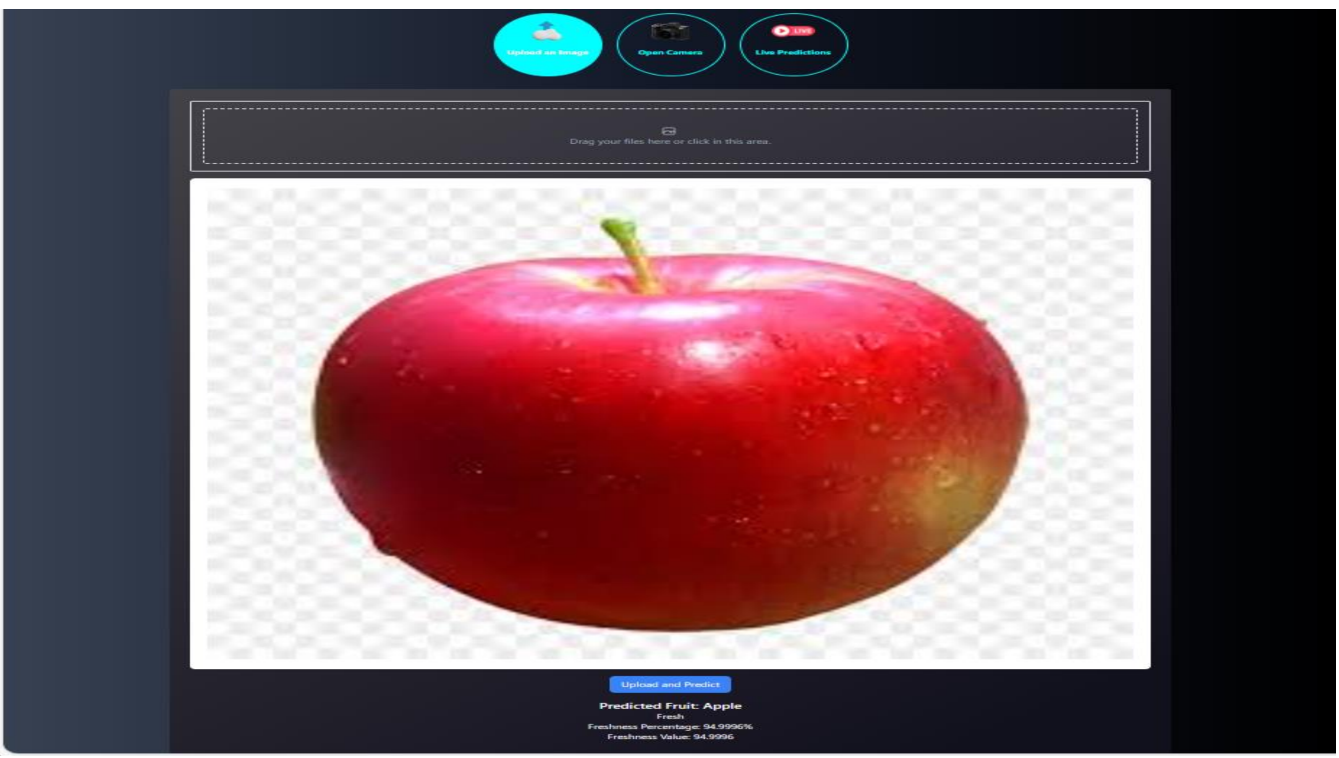
The implementation of the Fruit Defect Detection System project revolves around key components and techniques:

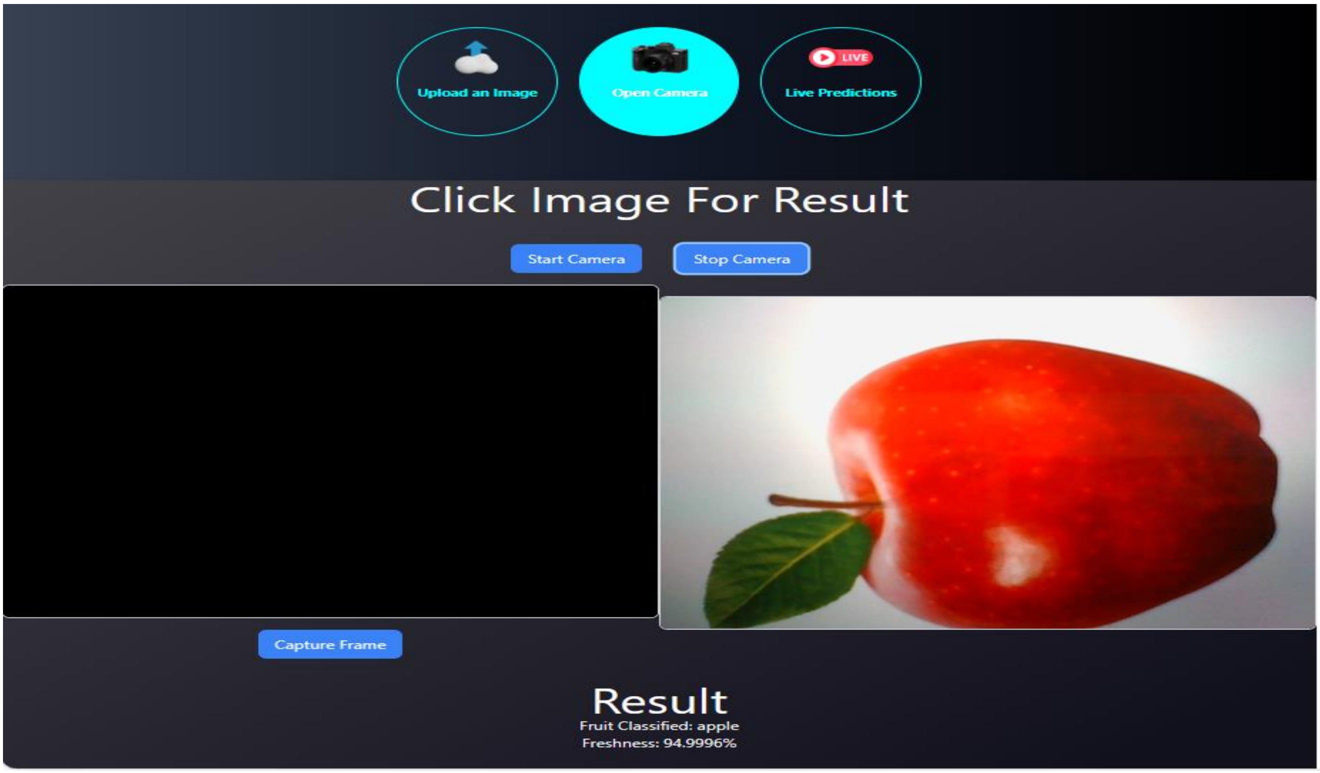
- **Data Collection and Labeling -** The project begins with the collection and labeling of high-resolution fruit images to build datasets for model training. These datasets encompass defect-free and defective examples.
- **Machine Learning with CNN -** Convolutional Neural Networks (CNN) form the core of the project's defect detection. Models are trained with curated datasets to recognize defects, leveraging supervised machine learning.
- **MobileNetV2 Integration -** MobileNetV2, a lightweight neural network, is integrated to enable swift real-time image analysis using the system's camera.
- **User-Friendly React Interface -** The project features an intuitive user interface developed with React. Users can capture fruit images, initiate analysis, and view results with ease.
- **Real-Time Image Processing -** The system's real-time image processing capability swiftly analyzes fruit images, providing instant defect detection and ripeness assessments.
- **Accuracy and Performance Evaluation -** The project emphasizes high accuracy and efficiency, assessed through precision, recall, F1 score, and performance metrics.
- **Data Privacy Measures -** Robust data privacy measures, including encryption, secure user data and images, ensuring user privacy and compliance.
- **Scalability and Future Adaptation -** The system is designed for scalability, accommodating increased inspection volumes and ongoing improvements.
- **Ethical Compliance -** The project adheres to ethical standards, respecting data privacy regulations and intellectual property rights.

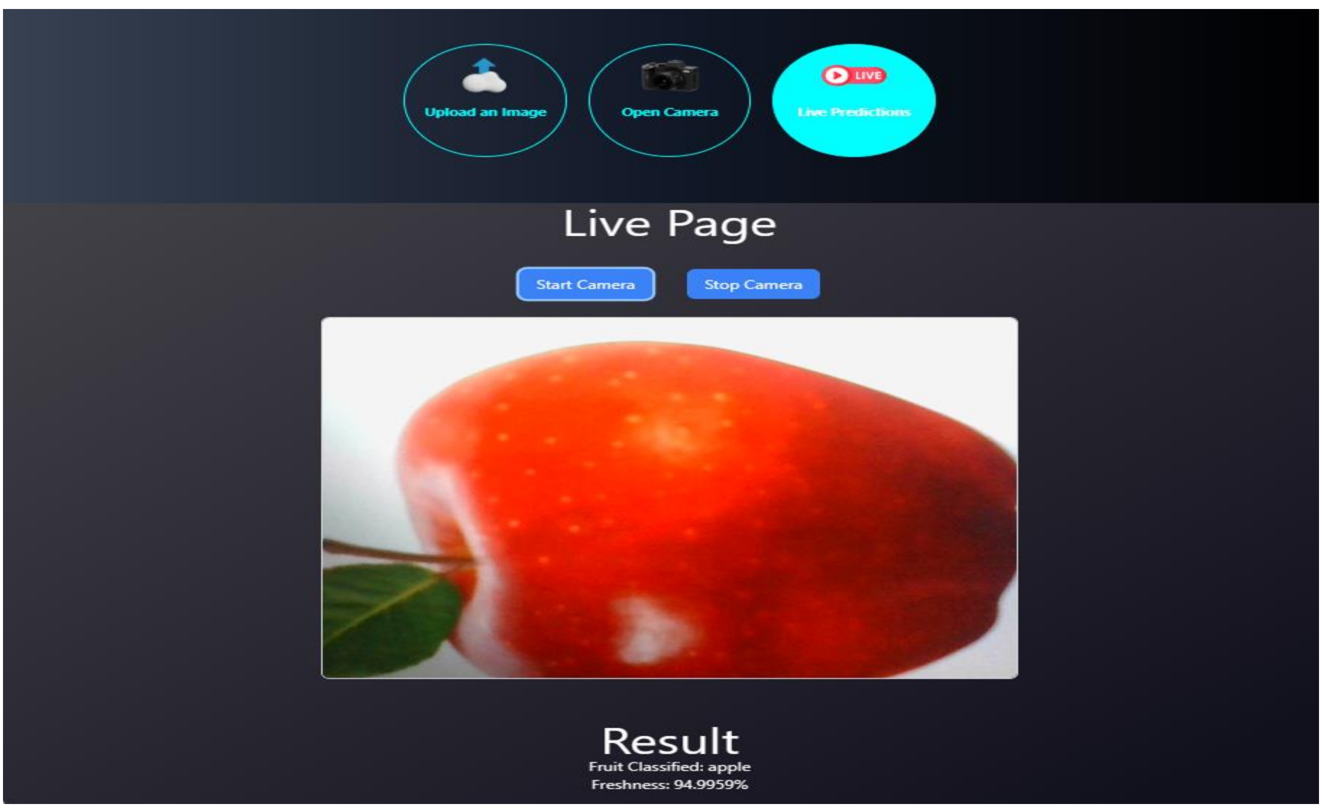
By uniting these elements, the project aspires to transform fruit quality assessments, bolster food safety, reduce waste, and enhance consumer experiences.

Chapter 8
Result


Fruit_ Classifier
Home
Upload
Camera
Live
Precision Fruit Defect Detection for a Bet
Go
Home
The Next
Generation
Defect Detection
Technology
Perfecting Nature's Bounty: Unveiling the Flawless
Fruits with Defect Detection Technology


Upload an Image
Open Camera
LIVE
Live Predictions
Drag your files here or click in this area.
Upload and Predict
Predicted Fruit: Apple
Fresh
Freshness Percentage: 94.9996%
Freshness Value: 94.9996


Upload an Image
Open Camera
LIVE
Live Predictions
Click Image For Result
Start Camera
Stop Camera
Capture Frame
Result
Fruit Classified: apple
Freshness: 94.9996%


Upload an Image
Open Camera
LIVE
Live Predictions
Live Page
Start Camera
Stop Camera
Result
Fruit Classified: apple
Freshness: 94.9959%

Chapter 9

Conclusion

Our project findings indicate that traditional manual methods for detecting fruit defects are being substituted with automatic, vision-based technology. This new approach relies on image processing techniques to identify defective fruits. The procedures carried out using this technology are highly accurate and efficient. Moreover, this system can be adapted and enhanced as technology continues to evolve, especially in scenarios involving a large volume of fruit, such as food factories.

The system offers several advantages, including cost-effectiveness, effectiveness in identifying defects, and user-friendliness. It represents a cost-effective solution that efficiently identifies defective fruits, making it a valuable tool for various applications, particularly in food processing factories. The system is designed to be user-friendly, ensuring that operators can easily interact with and benefit from its capabilities

Chapter 10
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  https://dl.acm.org/doi/10.1145/3331453.3361658: Md. Saiful Islam, Md. Mahmudur Rahman, Md. Abdullah-Al Mamun, and A. B. M. Siddique Hossain. Fruit Image Classification Based on MobileNetV2 with Transfer Learning Technique. In Proceedings of the 2022 2nd International Conference on Artificial Intelligence and Data Science (AIDAS), pp. 177-182, 2022.
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