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AI-Based Product Quality Inspection System

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Abstract

Smart web application for recognition of Fruits and Vegetables and checking their freshness automatically based on Artificial Intelligence and Computer Vision, called AI-Based Product Quality Inspection System. What it does is utilize a state-of-the-art model(OpenCLIP (ViT-B-32)) to detect various classes of produce and their quality condition without having massive training datasets. OpenCV is also used to analyze the images for defects such as discoloration, mold, browning, or over-ripeness, then gives it a freshness rating and categorizes it as Fresh / Consume at Your Own Risk / Non-Consumable. The application is built with Flask, PyTorch, PIL, and OpenCV.

Keywords: *Artificial Intelligence, Computer Vision, OpenCLIP, Zero-Shot Learning, Freshness Estimation, Defect Detection, Food Quality Inspection.*

Introduction

Nowadays, health concerns and the issue of wasting food have made it essential to ensure that food is both safe and good. Traditional methods for checking the freshness of fruits and vegetables often involve hand-holding, which can be time-consuming and unreliable due to personal opinions. With the development of Artificial Intelligence and Computer Vision, automated quality inspection systems have become efficient and reliable options. How does this compare? A system that uses AI to inspect produce quality can automatically recognize the type and state of fruits and vegetables by analyzing images. The system applies deep learning techniques using OpenCLIP, a model that connects images and text, eliminating the need for extra training on individual tasks while still maintaining consistent quality. This allows the system to identify different types of produce and their variety from written descriptions.

Problem Statement

Checking fruits and vegetables by hand isn't dependable and can be different each time someone does it. It could cause wrong judgments about quality, throw away good food, lose money, and make people sick by eating bad produce.
We need a smart and automatic system that can recognize fruits and vegetables from pictures, spot any problems, guess how fresh they are, and give accurate information about their quality. The new AI-Based Produce Quality Inspection System tackles this problem by using deep learning and computer vision.

1. Literature Survey

Before starting the development of the **"AI-Based Product Quality Inspection System"**, a literature survey was conducted. This survey includes the study of existing research papers related to artificial intelligence, image processing, deep learning models, and automated quality inspection systems. The purpose of this survey is to understand current technologies, methods, advantages, and limitations in the field of automated agricultural product inspection.

Research Paper 1: Fruit Quality Assessment Using Machine Learning and Image Processing Techniques

Authors' Name: M. S. Hossain, M. A. Alim, and M. A. Rahman
Description: This research paper presents an automated system for fruit quality assessment using image processing and machine learning algorithms. The study uses techniques such as image segmentation, color analysis, texture feature extraction, and classification models like Support Vector Machine (SVM) and Artificial Neural Networks (ANN). The system is capable of identifying defects, ripeness level, and overall quality of fruits with good accuracy. The paper emphasizes the importance of automation in reducing manual effort, improving grading speed, and maintaining consistency in quality inspection. This

research contributes to the development of intelligent produce quality inspection systems using AI-based methods.

Research Paper 2: Learning Transferable Visual Models From Natural Language Supervision (CLIP)
Authors' Names: Alec Radford, Jong Wook Kim, Chris Hallacy, Aditya Ramesh, Gabriel Goh, Sandhini Agarwal, Girish Sastry, Amanda Askell, Pamela Mishkin, Jack Clark, Gretchen Krueger, and Ilya Sutskever
Description: This research paper introduces CLIP (Contrastive Language–Image Pretraining), a model trained to understand images using natural language supervision. Instead of
traditional CNN-based classification, CLIP learns visual concepts by associating images with
text descriptions. The model is trained on a large dataset of image–text pairs and can perform zero-shot classification without requiring task-specific training. OpenCLIP is an open-source implementation of this model and allows developers to use pretrained vision-language models for custom applications. This research is highly relevant to the AI-Based Produce Quality Inspection System, as it enables accurate image understanding and classification of fruits and vegetables without extensive labeled datasets.
Research Paper 3: Automated Fruit and Vegetable Classification Using Computer Vision
Authors' Name: S. Bargoti and J. Underwood
Description: This paper focuses on the use of computer vision and machine learning techniques for the classification of fruits and vegetables. The system uses image preprocessing, feature extraction, and classification algorithms to detect defects and categorize produce based on quality. The study highlights the importance of real-time processing and accuracy in agricultural applications. This research supports the development of AI-based inspection systems for grading and sorting agricultural products

2. Body of Paper

- Image Upload and Validation :

Users send an image using a website that is made with Flask.

- AI-Based Classification :

The OpenCLIP model creates image embeddings and checks them against already made text embeddings to figure out what kind of product it is.

- Defect Detection :

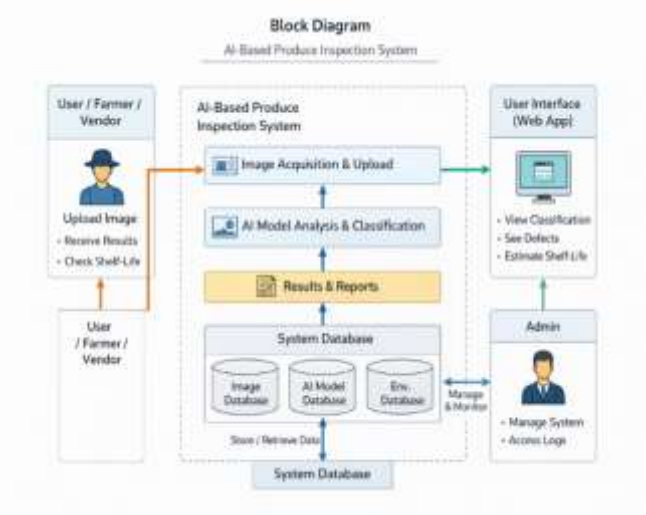
OpenCV is used to look at the HSV color space to find signs of decay, mold, color changes, and damage on the surface.

- Freshness Estimation :

A scoring system uses confidence levels and defect ratios to sort produce into different quality groups.

- Nutritional and Storage Insights :

The system gives clear details on vitamins, minerals, their benefits, and how to store them properly.



2. Applications

- Warehouses and Cold Storage Units:

In warehouses and cold storage places, the system can watch over the stored products to stop big problems with spoilage. Finding problems early can help save money and reduce waste.

- Food Processing Industries:

Food processing companies can use the system to check raw materials before they start processing. It makes sure that only new and good-quality product is used in making things, which helps make the final product better.

- Agricultural Sector:

Farmers can use the system to check the quality of their crops before they sell them or move them to the market. This helps with evaluating the product and ensuring it meets quality standards. It also helps cut down on waste after harvest by spotting problems that make food go bad early on.

- Supermarkets and Retail Stores:

This system helps supermarkets quickly check if fruits and vegetables are still fresh before putting them on sale. It helps store managers spot products that are bad or not up to standard and take them off the shelves,

which helps keep the quality high and makes customers happier.

3. Advantages

- Reduces Food Wastage:

The system helps find spoiled or bad fruits and vegetables early, which cuts down on wasted food and money lost.

- Cost-Effective Solution:

The project uses open-source technologies, which means there are no costs for licenses. It can work on regular hardware without needing a costly setup.

- Real-Time Processing:

The system gives results in just a few seconds, which helps people make fast decisions in retail and warehouse settings.

- Scalable and Extendable:

The system's design makes it easy to add new features like mobile support, using the cloud, and tracking with IoT devices later on.

4. Future Enhancements

Create a tailored AI model focused on farming data to boost the ability to correctly identify different produce and determine how fresh it is.
Conveyor Belt Automation Integration: Connect the system to automated conveyor belts so that quality checks can happen quickly and on the spot in warehouses and food processing plants.
Shelf-Life Prediction Modeling: Use special tools to guess how much longer fruits and vegetables will stay fresh, taking into account what they look like and the conditions around them.
Create a mobile app that lets farmers and vendors check the quality of products right on their smartphones.
Using advanced imaging techniques like hyperspectral or thermal imaging helps find defects inside materials that can't be seen on the surface.

5. Conclusion

This project successfully demonstrates how artificial intelligence and computer vision can automate produce quality inspection. By combining zero-shot learning and pixel-level defect detection, the system generates standardized and explainable freshness assessments.

The solution can serve as a first-level automated screening tool in retail and supply chain environments.