



AI-Driven Fruit Quality Grading and Automated Conveyor Based Sorting System with Real Time Monitoring

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ABSTRACT: Fruits are still sorted and graded manually at retail markets and in the fruit processing industry, which leads to poor quality, high labor costs, and post-harvest losses. Accurate classification using traditional methods is challenging because of variations in color, texture, maturity, and surface defects. This study presents the design and development of an AI-driven automated fruit sorting system utilizing computer vision and Convolutional Neural Networks (CNN) for real-time categorization and quality evaluation. Fruits placed on a conveyor belt can be captured by the system using USB cameras. To categorize various fruit varieties and identify rotting fruits, image processing methods and a trained CNN model extract visual characteristics, such as color, shape, texture, and surface defects. Quality grades were assigned based on the classification results. Fruits are automatically sent to the appropriate bins when the sorting process is activated by the Arduino control unit. Additionally, the system offers a fruit-count display and real-time monitoring. The proposed approach provides a low-cost and scalable method for intelligent agricultural and food processing applications, while decreasing manual intervention, increasing processing speed, and improving grading accuracy.

KEYWORDS: Automated Fruit Sorting, Computer Vision, Convolutional Neural Networks (CNN), Conveyor Belt System, Fruit Grading.

I. INTRODUCTION

Fruit quality evaluation is crucial in the food processing and agricultural sectors. Fruits are traditionally sorted manually using visual examination, which is labor-intensive, time-consuming, and prone to human error. Automated technologies that increase fruit grading efficiency and accuracy are required owing to the growing demand for high-quality agricultural products. Recent advancements in embedded systems, image processing, and artificial intelligence have made smart agricultural solutions possible. To assess fruit quality, computer vision methods and deep learning models, such as Convolutional Neural Networks (CNNs), can examine fruit characteristics, such as color, size, shape, and surface defects. This proposal suggests an automated conveyor sorting system with real-time monitoring and AI-based fruit quality grading. A CNN model was used to evaluate fruit images captured using a USB camera to determine the type and quality of the fruit. An Arduino controller that controls the conveyor and sorting system receives data from the gas sensor, which aids in identifying rotten fruits. This technology minimizes post-harvest losses, increases grading accuracy, and lowers manual labor.

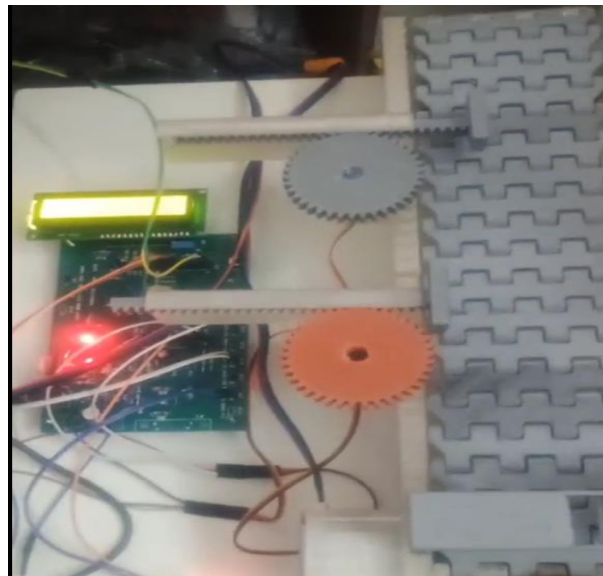
II. RESEARCH BACKGROUND

Numerous studies have investigated the use of deep learning and image processing techniques for automated fruit classification and grading processes. Convolutional Neural Networks (CNNs) have been used by researchers to recognize fruits and identify defects based on characteristics such as texture, color, and size. Compared to conventional manual inspection techniques, these approaches have demonstrated increased accuracy. Certain systems achieve excellent accuracy in detecting various fruit types and quality levels using deep learning models, such as ResNet and MobileNet, for fruit classification. Other studies have focused on automated grading systems that examine fruit attributes to assess

freshness and identify rotten or damaged fruits. Although these techniques increase the efficiency and accuracy of sorting, many of them simply use image analysis and require expensive computer systems. Therefore, a low-cost automated fruit sorting system that integrates sensors, embedded hardware, and deep learning for real-time quality detection and sorting is required.

III. SYSTEM ARCHITECTURE

The proposed fruit sorting system architecture comprises a few hardware and software elements that collaborate to automatically classify and identify fruits. To capture images, the fruits were first placed on a conveyor belt and moved below a USB camera. The photos are transferred to a PC or laptop, where the CNN classification model and image processing module examine the fruit according to characteristics, including color and surface condition. After determining whether the fruit is fresh or rotten, the system grades its quality. After processing the classification results, a decision engine uses serial connectivity to transmit commands to the Arduino Uno. The motor driver circuit, which runs the servo and stepper motors to sort the fruits, is managed by an Arduino. Fruits were sorted into distinct bins using a stepper motor and servo motors controlled by an Arduino motor driver circuit. To assist in the quality monitoring procedure, a gas sensor simultaneously detects the gases released from rotten fruits. For real-time observation, the system also displays the results on an LCD display and monitoring interface, including fruit count, quality grade, and system condition.



IV. METHODOLOGY

The proposed system performs automatic fruit sorting and quality identification in several processes. To compile a dataset of both fresh and rotten fruit photos, fruit photos were first gathered. A Convolutional Neural Network (CNN) model was trained using these images. To enhance the model's performance, the photos were pre-processed by shrinking and normalizing them. Then, using visual characteristics such as color, texture, and surface condition, the CNN system was trained to detect various fruits and spot defects. The fruits are placed on a conveyor belt while the system is operating, and a USB camera captures images of each fruit. The trained CNN model was used to analyze the images to categorize the fruit and evaluate its quality. To support the freshness detection procedure, a gas sensor was used to detect the gases emitted by rotten fruits. Ultimately, the Arduino controller receives the results and uses motors and sorting mechanisms to sort fruits into different bins according to their quality grade. On the monitoring interface, the system also shows real-time data such as fruit count, quality grade, and freshness level.

V. RESULTS AND DISCUSSION

A dataset of photographs showing both fresh and rotten fruits was used to evaluate the proposed approach. Using visual characteristics, such as color and surface quality, the CNN model successfully identified the fruits. This technology demonstrated good accuracy in identifying various fruit varieties and detecting rotten goods. The combination of a gas sensor and image processing improved the ability to identify rotten fruits during testing. Fruits were successfully divided



into various bins according to their quality grade using an automated conveyor-based sorting system. Overall, the system demonstrated effective fruit classification, reduced manual labor, and improved sorting accuracy, making it suitable for use in food processing and agriculture.

VI. CONCLUSION

Using image processing and a CNN algorithm, the proposed AI-based fruit sorting system automates fruit classification and quality assessment. It reduces manual labor and human error while accurately identifying both fresh and rotten fruits. Efficiency is increased, and real-time monitoring is provided by the integration of sensors, embedded electronics, and automated sorting. In the food processing and agricultural sectors, this technology can improve quality control, increase production, and decrease the amount of fruit waste.

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