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Precision Harvesting: Utilizing Inception Neural Networks in Robotic Arms for Fruit Sorting

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***Abstract*—Fruit sorting is a crucial procedure in the food and agriculture sectors that frequently affects the shelf life and quality of products throughout the supply chain. This sorting has historically been done by hand, with human employees visually evaluating and classifying fruits as fresh or rotting. However, manual sorting has many disadvantages such as high classification quality variability brought on by human error, a slower rate of operation, health risks from repetitive tasks, and extended exposure to rotting produce. This study presents an automated fruit-sorting system that addresses the limitations of manual sorting, such as human error, slow speed, and health risks. The system employs Convolutional Neural Networks (CNNs) for accurate fruit classification, with Inception demonstrating superior performance among various algorithms evaluated. Based on visual characteristics like color and texture, the CNN model effectively distinguishes between fresh and rotten fruits. A robotic arm then physically separates the fruits, enhancing efficiency and consistency. This innovative approach offers significant advantages, including increased accuracy, higher throughput, reduced labor dependence, and improved scalability, making it a promising solution for large-scale fruit processing plants. This version specifically mentions the evaluation and selection of Inception as the most accurate algorithm for fruit classification.**

***Index Terms*—Convolutional Neural Network, Fruit classification, Robotic Arm**

I. Introduction

The planting, harvesting, and effective marketing of the products have made agriculture one of the most important topics for discussion in the last decades. Various areas and businesses are implementing automation to boost effectiveness, productivity, and accuracy. This enhances efficiency, productivity, and accuracy in farming operations via the use of technology and machines. India is the fourth-largest state in terms of horticulture production, generating 23 tons of fruits and vegetables annually. Nevertheless, mechanical, microbiological, and physiological processes result in a 16–36% post-harvest loss of fruits. Due to inadequate manual handling techniques, an additional 30% are unfit for use after harvest. Consequently, product marketing may become more successful and effective if automation is used. Additionally, this can aid in lowering fruit rotting and supplying consumers with high-quality goods. Fruit sorting is crucial for upholding good standards as emphasised in (1). The existing manual sorting procedure is labour-intensive and time-intensive, increasing costs and decreasing efficiency.

Convolutional Neural Network (CNN) was used to classify fruits by freshness in (2) . The Inception model(3), which is known for its deep feature extraction skills, is used here to categorise fruits by analysing minor changes in texture and colour between fresh and rotting samples. A camera takes high-resolution photos of the fruits as proposed in (4), which are then preprocessed using techniques such as normalisation and augmentation to ensure consistent model performance un- der varying lighting and environmental circumstances(5). The preprocessed photos are then sent into the Inception model, which generates classification labels indicating freshness. This model, trained on a dataset sourced from Kaggle, classifies input fruit images into ”fresh” and ”rotten” categories with 99% accuracy. For the replication of the manual sorting process we use robotic arm which proposed in the study(6).

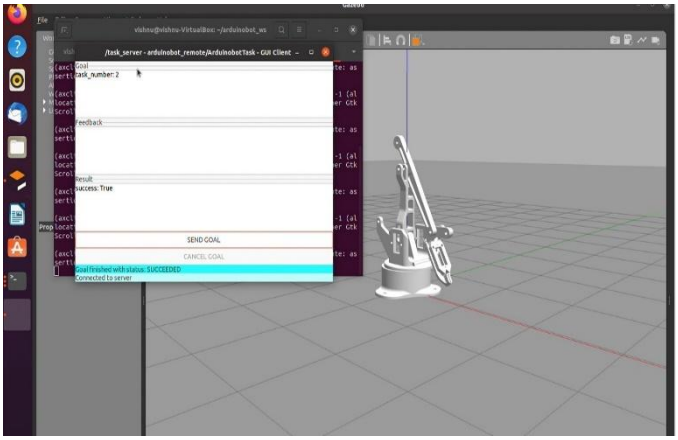

Fig 23. Position 2

Each figure represents how responsive and accurate the arm was at matching predefined coordinates, which is necessary for holding and evaluating the fruit. The arm's response showed slight delays in achieving specific angles, indicating that hardware calibration or algorithmic modifications could be able to improve the situation.

V. CONCLUSION

In conclusion, combining a robotic arm and convolutional neural networks (CNNs) represents a breakthrough in agricultural automation, especially regarding fruit sorting. In addition to improving accuracy and efficiency, this cutting-edge approach helps the sector deal with its growing labor scarcity. This minimizes human error and lessens the need for manual work.

This technology offers more advantages than just replacing manpower. Only the best produce will reach consumers thanks to automation in fruit sorting, which can increase product quality and consistency.

VI. FUTURE SCOPE

The next stage of this research entails transferring from simulation to practical implementation. It will be crucial to create a functional model that functions well in a changing agricultural environment. In addition to testing the robotic system's resilience and dependability, its deployment will offer priceless insights into how well it functions in real-world scenarios. In the end, these developments will support innovation and economic viability by making the agriculture sector more efficient and sustainable.

The industry may alter fruit sorting by using these technology developments, resulting in a supply chain that is more automated, effective, and responsive. To fully realize the potential of robotic automation in improving agricultural practices, cooperation between engineers, agricultural specialists, and stakeholders will be crucial as we proceed.

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