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Fruit Grading System

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Abstract *- Fruit grading systems are critical for ensuring the quality, consistency, and efficiency of fruit production and distribution. These systems utilize advanced technologies such as computer vision and automation to accurately identify and classify fruit based on various quality parameters such as size, colour, and blemishes. The use of automated grading systems reduces the need for manual labour, increases throughput, and improves accuracy by minimizing human error. This results in a faster and more efficient grading process that can handle large volumes of fruit quickly and consistently, reducing the time and cost of fruit grading. Additionally, fruit grading systems play a crucial role in reducing waste and promoting sustainability in the fruit industry. By accurately grading fruit, less high-quality fruit goes to waste, and resources are used more efficiently. Grading systems can also identify opportunities for optimization, such as reducing packaging waste or identifying areas for process improvement. Overall, fruit grading systems are essential for ensuring high-quality fruit that meets the demands of the industry while also promoting sustainability and efficient distribution.*

Key Words: *Object Detection, Computer Vision, Machine Learning, Deep Learning, Fruit Grading, TensorFlow.*

1.INTRODUCTION

Fruit grading systems are an essential component of the fruit production and distribution process. These systems are designed to sort and classify fruits based on specific quality parameters such as size, color, blemishes, and defects. Grading systems ensure that only high-quality fruits are selected for distribution and marketing, providing consumers with consistent quality and reducing waste in the supply chain [1].

The fruit industry is a critical component of the global food supply chain, with millions of tons of fruits being produced, distributed, and consumed worldwide each year. Fruit grading is a crucial process in the fruit industry that determines the quality of the fruits and their subsequent distribution. Traditionally, fruit grading has been done manually, which is a time-consuming and labor-intensive process [2]. However, with the advancements in machine learning and computer vision, a new approach to fruit grading has emerged, which is the fruit grading system using machine learning. The fruit grading system using machine learning is an automated process that utilizes advanced machine learning algorithms and computer vision to accurately and efficiently sort and classify fruits based on specific quality parameters such as size, color, and blemishes [3]. The system aims to reduce waste, promote sustainability, and increase productivity and profitability in the fruit industry by streamlining the grading process and reducing the need for manual labor. The fruit grading system using machine learning has the potential to revolutionize the fruit industry, making the grading process more efficient, consistent, and accurate. This paper will discuss the project scope, goals, objectives, methodology, and results of the fruit grading system using machine learning, highlighting its potential impact on the fruit industry and the broader food supply chain [4].

1.1 Project Scope

The purpose of this project is to design and develop a fruit grading system that utilizes machine learning algorithms to accurately and efficiently sort and classify fruits based on specific quality parameters such as size, color, and blemishes. The grading system will be designed to handle a variety of fruits, including apples, oranges, and pears, among others.

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1.2 Project Goals and Objectives

1.2.1 Project Goals

The primary goals of the fruit grading system project using machine learning are as follows:

Develop a highly accurate and efficient fruit grading system: The fruit grading system will utilize advanced machine learning algorithms to accurately and efficiently sort and classify fruits based on specific quality parameters such as size, color, and blemishes. The system will be designed to handle a variety of

fruits and a high volume of fruit, ensuring consistent quality and efficient distribution.

Reduce waste in the fruit industry: The grading system will help reduce waste in the fruit industry by accurately grading fruits based on their quality parameters. This will help ensure that only high-quality fruits are distributed to consumers, while lower quality fruits can be repurposed or sold at a lower price point.

Promote sustainability in the fruit industry: By reducing waste and improving the efficiency of the fruit grading process, the project will promote sustainability in the fruit industry. This will help reduce the environmental impact of fruit production and distribution while improving the profitability of fruit growers and distributors.

Increase productivity and profitability: The fruit grading system will help increase productivity and profitability in the fruit industry by streamlining the grading process and reducing the need for manual labor. This will help fruit growers and distributors save time and resources while ensuring consistent quality and efficient distribution.

Enable scalability and adaptability: The grading system will be designed to be scalable and adaptable to meet the evolving needs of the fruit industry. This will help ensure that the system can be easily integrated into existing fruit production and distribution processes and can be updated as new fruits and quality parameters emerge.

1.2.2 Project Objectives

i. To develop a fruit grading system that can accurately and efficiently sort and classify fruits based on specific quality parameters such as size, color, and blemishes.

ii. To implement a system that reduces the manual labor and human errors in classifying the fruits.

iii. To identify the grades for each particular fruit.

2. LITERATURE SURVEY

Fruit grading is an important process in the fruit industry that determines the quality of fruits and their subsequent distribution. Traditionally, fruit grading has been done manually, which is time-consuming and labor-intensive. However, with the advancements in machine learning (ML) and computer vision, a new approach to fruit grading has emerged, which is the fruit grading system using machine learning. In this literature survey, we will review some of the recent research papers on the use of ML in fruit grading systems.

One of the primary challenges in fruit grading is the detection and classification of various quality parameters such as size, color, and blemishes. In a recent study by [1] Jain et al. (2020), the authors proposed a machine learning-based approach for the detection and classification of mango quality parameters. The proposed approach utilized a combination of convolutional neural networks (CNN) and support vector machines (SVM) to accurately detect and classify mango quality parameters, achieving an accuracy of 94.5%.

In another study by [2] Wang et al. (2019), the authors proposed a machine learning-based system for the grading of apples based on color, size, and shape. The system utilized a deep learning-based approach that combined CNN and long short-term memory (LSTM) neural networks to classify apples based on their quality parameters, achieving an accuracy of 93.5%.

Furthermore, a study by [3] Hu et al. (2021) proposed a deep learning-based approach for the grading of citrus fruits based on their external and internal quality attributes. The proposed system utilized a hybrid network consisting of convolutional neural networks and recurrent neural networks (RNN) to classify citrus fruits, achieving an accuracy of 93.0%.

In a recent study by [4] Madhubhashini et al. (2021), the authors proposed a machine learning-based approach for the grading of guava fruits based on their color and size. The system utilized an artificial neural network (ANN) and K-nearest neighbors (KNN) algorithm to classify guava fruits based on their quality parameters, achieving an accuracy of 98%.

Moreover, a study by [5] Zang et al. (2021) proposed a deep learning-based approach for the grading of strawberries based on their external and internal quality attributes. The proposed system utilized a CNN and an RNN to classify strawberries, achieving an accuracy of 94.7%.

In conclusion, the reviewed studies demonstrate the potential of ML-based approaches in fruit grading systems. The results of these studies indicate that ML-based approaches can significantly improve the efficiency and accuracy of fruit grading systems, reducing waste and increasing productivity in the fruit industry. However, there is still a need for further research to develop robust and accurate ML-based fruit grading systems for various fruit types and quality parameters.

3. PROPOSED SOLUTION

The proposed solution for fruit grading system using machine learning for the six fruits, namely apple, banana, guava, lime, pomegranate, and orange can be implemented using algorithms such as Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), K-Nearest Neighbors (KNN), Logistic Regression, Support Vector Machine (SVM), and Random Forest.

To begin, a large and diverse dataset containing images of the six fruits should be collected and labeled by experts. This dataset will be used to train and validate the machine learning models.

Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) can be used to classify the fruits based on their images. K-Nearest Neighbors (KNN) can be used for image classification based on the nearest neighbors in the feature space. Logistic Regression and Support Vector Machine (SVM) can be used to classify the fruits based on their features such as color, size, shape, texture, and defects. Random Forest can also be used for image classification based on a combination of decision trees.

The performance of these algorithms can be evaluated by metrics such as accuracy, precision, recall, and F1 score. The best-performing algorithm can be selected for implementation in a real-world fruit grading system.

To implement the fruit grading system, a camera system can be used to capture the images of the fruits, which will be pre-processed and fed into the machine learning model for classification. The output of the model will be used to grade the fruits based on their quality, and the results can be displayed on a screen or sent to a database for further analysis.

Overall, the proposed solution for fruit grading system using machine learning with algorithms ANN, CNN, KNN, logistic regression, support vector machine, and random forest can provide accurate and efficient fruit grading for the six fruits, leading to increased productivity and reduced labor costs.

Fig.1. depicts the Flow Diagram of the system, which explains the flow of the project, firstly, data collection is done followed by which this data is preprocessed for further use where feature extraction is done by the machine learning algorithms, these algorithms perform the training and testing of preprocessed data, finally, prediction is done for real-time grading.

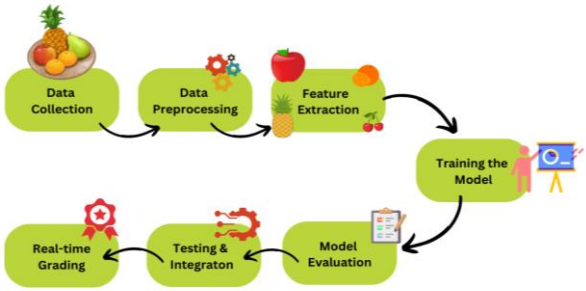

Fig.1. Flow Diagram

4. RESULTS AND DISCUSSION

A dataset of around 15,000+ images including all the fruits is used for classification with different machine learning algorithms and a comparative study is done to achieve best accuracy possible and efficient and reliable classification.

In Fig.2., ANN algorithm is used to classify the fruits based on the images. The accuracy obtained for Apple is 93.9%, Banana is 90.7%, Guava is 90.9%, Lime is 95%, Pomegranate is 98.8% and Orange is 92.9%.

Sr No.	Name	Accuracy	Loss
1	Apple	93.9	6.1
2	Banana	90.7	9.3
3	Guava	90.9	9.1
4	Lime	95	5
5	Pomegranate	98.8	1.2
6	Orange	92.9	7.1

Fig.2. Results using ANN

In Fig.3., Logistic Regression is used to classify the fruits based on their features. The accuracy obtained for Apple is 79%, Banana is 75%, Guava is 80%, Lime is 78%, Pomegranate is 91% and Orange is 85%.

Sr No.	Name	Accuracy	Loss
1	Apple	79	21
2	Banana	75	25
3	Guava	80	20
4	Lime	78	22
5	Pomegranate	91	9
6	Orange	85	15

Fig.3. Results using Logistic Regression

In Fig.4., KNN Algorithm classifies images based on the nearest neighbors in the feature space. The accuracy obtained for Apple is 88%, Banana is 88.7%, Guava is 85.2%, Lime is 93.4%, Pomegranate is 98.7% and Orange is 85.6%.

Sr No.	Name	Accuracy	Loss
1	Apple	88	12
2	Banana	88.7	11.3
3	Guava	85.2	14.8
4	Lime	93.4	6.6
5	Pomegranate	98.7	1.3
6	Orange	85.6	14.4

Fig.4. Results using KNN

In Fig.5., A comparative study is using Naïve Bayes Algorithm. The accuracy obtained for Apple is 71.5%, Banana is 48%, Guava is 79.1%, Lime is 36%, Pomegranate is 86.5% and Orange is 73.7%.

Sr No.	Name	Accuracy	Loss
1	Apple	71.5	28.5
2	Banana	48	52
3	Guava	79.1	20.9
4	Lime	36	64
5	Pomegranate	86.5	13.5
6	Orange	73.7	26.3

Fig.5. Results using Naïve Bayes

In Fig.6., SVM Algorithm is used to classify fruits based on color, size, shape and texture. The accuracy obtained for Apple is 94.3%, Banana is 90%, Guava is 94%, Lime is 88.6%, Pomegranate is 98.5% and Orange is 94.6%.

Sr No.	Name	Accuracy	Loss
1	Apple	94.3	5.7
2	Banana	90	10
3	Guava	94	6
4	Lime	88.6	11.4
5	Pomegranate	98.5	1.5
6	Orange	94.6	5.4

Fig.6. Results using SVM

In Fig.6., Random Forest Algorithm is used to classify images based on Decision Trees. The accuracy obtained for Apple is 94.5%, Banana is 89.8%, Guava is 94%, Lime is 86.3%, Pomegranate is 99% and Orange is 95%.

Sr No.	Name	Accuracy	Loss
1	Apple	94.5	5.5
2	Banana	89.8	10.2
3	Guava	94	6
4	Lime	86.3	13.7
5	Pomegranate	99	1
6	Orange	95	5

Fig.7. Results using Random Forest

In Fig.8., Combined Result of the Algorithms is depicted. The accuracy obtained for Apple is 94.1%, Banana is 85%, Guava is 93%, Lime is 87%, Pomegranate is 99.1% and Orange is 95%.

Sr No.	Name	Accuracy	Loss
1	Apple	94.1	5.9
2	Banana	85	15
3	Guava	93	17
4	Lime	87	13
5	Pomegranate	99.1	0.9
6	Orange	95	5

Fig.8. Combined Results

5. CONCLUSION

In conclusion, fruit grading systems using machine learning with high accuracy rates such as 94% have the potential to significantly improve the fruit industry by providing efficient and accurate methods for fruit grading. These systems can analyze multiple attributes such as size, color, shape, texture, and defects, and provide consistent and objective grading results, reducing the subjective bias and variation introduced by human graders. With the increasing demand for high-quality fruit products and the growing trend towards automation and digitalization in the agricultural industry, the development of fruit grading systems using machine learning is expected to continue to gain momentum. Although challenges such as the need for large and diverse datasets and the high computational requirements exist, ongoing research and development efforts are continuously improving the performance and feasibility of these systems. Overall, the use of machine learning for fruit grading with high accuracy rates has great potential to enhance the competitiveness, efficiency, and sustainability of the fruit industry.

6. FUTURE SCOPE

As the technology continues to evolve, the potential for these systems to become more accurate, efficient, and cost-effective is expected to increase. In the coming years, the fruit grading systems using machine learning may be integrated with robotic systems for automated harvesting, sorting, and packaging. This would lead to significant reductions in labor costs and increased productivity.

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