Fruit Grading, Disease Detection, and an Image Processing Strategy

Article · June 2023

2 authors, including:

Kutubuddin Kazi
Solapur
207 PUBLICATIONS **2,899** CITATIONS

Fruit Grading, Disease Detection, and an Image Processing Strategy

Sultanabanu Kazi[1], Kazi Kutubuddin[*2]
[1]Assistant Professor, Department of General Science and Engineering, BMIT, Solapur, Maharashtra, India
[2]Professor, Department of Computer Science and Engineering, BMIT, Solapur, Maharashtra, India

[*]Corresponding Author: drkkazi@gmail.com

ABSTRACT

It is difficult to maintain high quality in agriculture. Climate change has a wide range of effects on agriculture, including poorer crop yield and quality owing to drought, heat waves, flooding, and an increase in pests and plant diseases. Such climate change makes it impossible to produce amazing items and meet human needs. Farmers would eventually be unable to profit from fruit growing. It is critical to be aware of climate change and educate farmers on how to deal with it. To boost the output and quality of pomegranate fruits, farmers need an automated system rather than a human one for fruit grading. Fruit grading by hand is unsuccessful because it takes more time to identify and grade diseases and necessitates the skills of a professional. It also does not yield appropriate results. Accurate fruit quality assessment and disease identification are vital tasks for farmers and researchers, as are pomegranate cultivation. Therefore, in this study, we developed a novel method for identifying illnesses and classifying them according to colour, size, and disease. An image processing-based method for pomegranate fruit grading and illness detection is presented in this study using Python. Machine learning methods like SVM or CNN are utilised to categorise the pomegranate fruit into different gradation groups based on the characteristics that were obtained.

Keywords- CNN algorithm, Diseases, Image processing, K-mean algorithm, Pomegranate

INTRODUCTION

India is one of the countries that export a significant amount of pomegranate to the rest of the world. Its popularity stems from the fact that it has numerous medical benefits. India offers suitable agricultural land and weather conditions for fruit farming. Pomegranate producers must cultivate pomegranates over a broad land area to meet demand. Pomegranates were first grown on a significant scale in Maharashtra [1].

Because of global warming, it is difficult to maintain high quality in agriculture. Climate change has a wide range of effects on agriculture, including poorer crop yield and quality owing to drought, heat waves, flooding, and an increase in pests and plant diseases. Such climate change makes it impossible to produce amazing items and meet human needs. Farmers would eventually be unable to profit from fruit growing. It is critical to be aware of climate change and educate farmers on how to deal with it. Such literacy may aid in the improvement of agricultural products [2].

In another situation, a fruit consumer is looking for a fantastic fruit for the price they are paying. The buyer thoroughly inspects the fruit and pays for it. Such customer behaviour eventually affects the seller's profit. Traders buy a lot of fruit without considering the quality of the fruit. In such a case, it is critical to inspect the fruit quality from the traders' end [3]. It may aid in obtaining a fair price for the fruit. Fruit quality assessment is the most crucial activity in the post-harvesting stages before shipping them to market to get a better price since quality fruits bring greater profit to farmers. Human-made quality examination of fruits is less accurate and time-consuming than an inspection done by a machine or software. As a result, fruit grading is done using an automated method. This project provides a Python-based system in which we focus on fruit sick area, fruit size, and fruit colour by employing image processing techniques for accurate and rapid fruit quality determination in the post-harvesting stage. One of the most

important factors affecting agricultural product quality is stage infection [4]. Fruit infections are becoming more widespread during the growing stage, as elements such as climate and environmental circumstances are more volatile than ever [5]. The image processing process begins with the capture of digital high-resolution images. Captured photos are saved for future use. The image is then pre-processed for image enhancement and analysis. Pomegranate fruits are classified according to disease (Table 1) as follows:

Fruit Disease Classification
Cercospora

Cercospora fruit spot is a disease caused by cercospora on pomegranate fruit. This fungus mostly affects fruit and can cause major economic losses. Cercospora fruit spot shows as little, dark brown to black lesions on the pomegranate fruit's surface.

Fruit Rot

Fruit rot is a broad word that refers to a variety of fungal and bacterial infections that cause fruit rot. These illnesses can harm pomegranate, causing the fruit's quality to deteriorate.

Bacterial Blight

Bacterial blight is caused by the bacteria Xanthomonas citri subsp. It is a serious illness that can harm pomegranate fruit. Bacterial blight can also cause sunken, dark brown lesions on pomegranate fruit. The lesions may expand and cause the fruit to decay, leading to significant yield losses.

Table 1 shows different types of diseases that are occurring in pomegranate fruit with corresponding images.

Database Collection

Because there is no standard database accessible, we collect images of various pomegranate fruits from farms. Fig. 1 shows a variety of photos.

Dataset Feature

Table 2 shows some pomegranate fruit characteristics including fruit spot, size, shape and color.

Gradation

Table 3 fruit classification based on the following qualities.

Table 1: *Different types of diseases that are occurring on pomegranate fruit with corresponding images.*

Normal Fruit	Diseases	Infected image
	Cercospora	
	Fruit Rot	

	Bacterialblight	
	Alternaria Fruit Spot	

Table 2: *Some pomegranate fruit characteristics include fruit spot, size, shape and colour.*

S. No.	Fruit Spot	Fruit Size	Fruit Shape	Fruit Color
1	12	Large	Regular	Orange
2	0	Small	Regular	Pale Yellow
3	4	Medium	Regular	Orange
….	….	….	….	….
900	18	Small	Regular	Pale Yellow
998	9	Medium	Regular	Dark Orange

Figure 1: *Captured images of infected pomegranate fruit.*

Table 3: *Fruit classification based on the following qualities.*

Grades	Fruit Characteristics
Super -Size	Fruits are attractive, Very large, and Orange in color.
King Size	Fruits are attractive, Regular without blemish.
Queen Size	Fruits are attractive, Medium without blemish.

LITERATURE SURVEY

Several academics are working around the clock on the post-harvest grading of various agricultural and horticultural products. Lee et al. [1] introduced a novel method for evaluating the quality of fruits. Colour quantization and color analysis techniques have been used to assess fruit quality. They used Medjool date samples to assess fruit maturity and discover skin delamination faults. They employed a 3rd order polynomial to convert 3D RGB values into a simple 1D colour index in this technique. They demonstrate that such 3D RGB conversion is clearer and more intuitive in terms of date maturity evaluation than previous approaches.

Narendra et.al reveals the classification of cashew kernels using colour characteristics. A new technique for automatic monitoring of fruit stages and fruit grading was developed, and encouraging results were obtained. The pomegranate plats used were from the variety, which is the most extensively farmed in Spain. They were grown on a plantation owned by Valencia Polytechnic University, which is located within the municipal boundaries of Alicante.

Kumar et. al. [2] collected a pomegranate fruits image data set obtained from a local fruit market. The images are then pre-processed before being put into a feature extraction program. There are two types of extracted features: spatial domain features and wavelet features. The sorting procedure has been completed, and the findings have been analyzed. The work has only a few constraints. The author considered a vast number of features, all of which are not used in the grading procedure. The various stages of fruit growth and development between winter dormancy are described using Flecking's (1945) typical technique, in which the general stages are named.

Because research on pomegranate fruit growth stages and grading is limited, there is more opportunity to research pomegranate fruit growth stages and grading assessment. This is also consistent with the industrial applications of pomegranate fruit sorting. As a result of this, the current work is to provide monitoring and automation of fruit growth stages to improve grades based on illnesses, colour, and size.

The study of procedures used to detect disease in fruits and the grading of fruits. As a result, the current work aims to establish monitoring and automation of fruit growth stages to improve grades based on illnesses, colour, and size.

STUDY OF TECHNIQUE THAT IS USED TO ANALYZE DISEASE IN FRUITS AND GRADING OF FRUIT
Image Preprocessing

Image preprocessing is a collection of techniques used to prepare and enhance images before they are fed into a machine-learning model or used for future analysis. These techniques seek to increase the image's quality and fit for the task at hand, such as object recognition, image segmentation, or image classification. Some typical image preparation techniques include resizing, cropping, normalization, grayscale conversion, and so on. The specific strategies to utilize are determined by the features of the dataset and the needs of the machine learning model.

Feature Extraction

The process of translating raw data, such as photographs, text, or audio, into a set of representative features that capture relevant information for a specific job is referred to as feature extraction. Feature extraction in image processing refers to the extraction of meaningful and discriminative visual properties from images. These characteristics are subsequently fed into machine learning algorithms or analytical tasks. Some common feature extraction approaches include a histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), local binary patterns (LBP), convolutional neural network (CNN), and others. The technique used is determined by the task at hand, the quality of the data, and the computer resources available.

Image Denoising

Image denoising is the technique of removing or reducing noise from an image to improve its visual quality and make it more appropriate for further analysis or visual perception [4].

Gaussian Noise

As a type of random noise, Gaussian noise can be successfully removed or decreased

using a Gaussian filter. Using a Gaussian filter to remove Gaussian noise often entails the following steps:

- *Convolution-* By convolving the noisy image with the Gaussian kernel, the Gaussian filter is applied to it. The dimensions of the kernel control how much smoothing or blurring is applied to the image.
- *Weighted Averaging-* Within the kernel window, each pixel in the image is replaced with the weighted average of its neighboring pixels. The Gaussian distribution determines the weights, with higher weights assigned to pixels closer to the kernel's centre.
- *Scaling-* After convolution, the resulting pixel values may exceed the image's original dynamic range. Scaling may be required to return the pixel values to the desired range.

Shot Noise

Shot noise, also known as poison noise, is a form of noise that occurs in picture systems due to the stochastic nature of photon detection. Shot noise can alter the quality of captured images and, as a result, the accuracy of analytic algorithms in the context of fruit disease detection and grading. Considerations for shot noise in context include noise interference, contrast reduction, image preprocessing, multiple image acquisition, and so on. There are various approaches for reducing shot noise in photos.

Median Filter

The median filter is a widely used picture-denoising technique, particularly in the context of fruit disease diagnosis and grading. It efficiently reduces a variety of noises, including shooting noise. We can use the following steps to calculate the median filter for fruit disease detection and gradation: Acquire the fruit image, preprocess the image, specify the size of the filtering window, place the window over each pixel in the fruit image, extract the pixel values within the window, sort the pixel values, calculate the median value, replace the pixel value, repeat for all pixels, and output the filtered image.

Mean Filter

A typical technique for image smoothing and noise reduction is the mean filter, often known as the average filter. It replaces each pixel in a picture with the average value of the pixels adjacent to it within a specified timeframe. The mean filter is calculated as follows: Set the size of the filtering window, place it over each pixel in the image, extract the pixel values within the window, calculate the mean value, repeat for all pixels, handle the boundaries, and output the filtered image. The mean filter is a linear filter capable of reducing Gaussian noise and providing broad smoothing. It can, however, blur sharp edges and delicate features in the image [5].

Contrast Enhancement Schemes

Contrast enhancement schemes can be used to improve the visibility and distinguishability of features linked to disease and gradation levels in fruit disease detection and gradation. Histogram equalization, contrast stretching, adaptive histogram equalization, contrast limited adaptive histogram equalization, retinex-based methods, adaptive contrast enhancement, and so on are some regularly used contrast enhancement techniques [2].

Particle Filter

Using models to estimate the status of the fruit, the particle filter can be used for fruit gradation and disease detection [1].

METHODOLOGY

The suggested methodology seeks to capture a fruit image and evaluate the condition (infected or not), detect diseases, and grade pomegranate fruit based on colour and size. Python and different image-processing algorithms are used in the system. The proposed work is broken into the following sections:
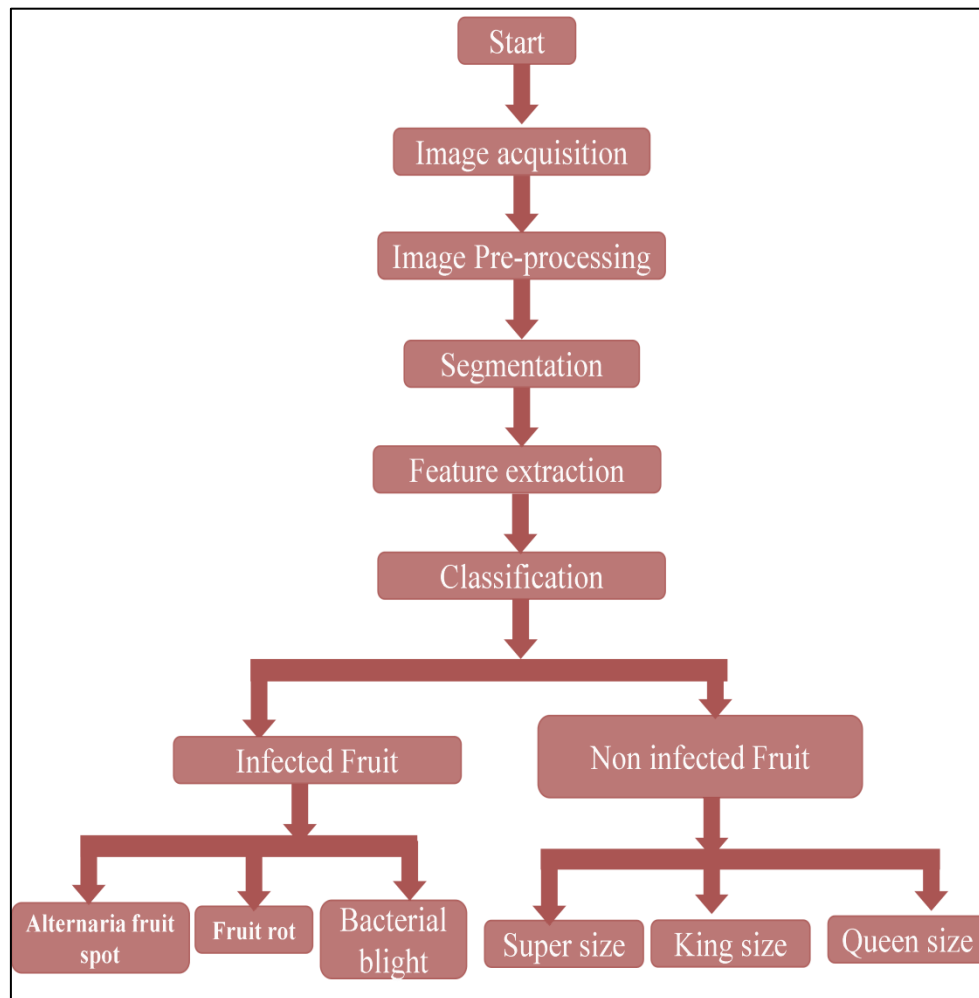
Figure 2: Flowchart of system.

Fig. 2 flow chart is depicting the classification of infected and non-infected pomegranate fruit using image processing techniques.

Image Acquisition

Image processing is a type of signal processing in which the input is an image, such as a photograph or video frame. The acquired image can be taken using a standard digital camera with a minimum resolution of 6 megapixels for greater quality while keeping a similar distance, angle, and illumination to the item with a homogeneous background. Images are typically in the RGB color space. For the colour transformation structure, this RGB image is then subjected to a device-agnostic colour space transformation [5].

Picture Pre-Processing

Image processing is a technique that involves digitizing the data from a picture and applying various operations to the data. Pre-processing improves an image so that it is more useful or pleasant to human observers. Pre-processing techniques include using an RGB-to-grey converter, filtering the acquired image, scaling the acquired image, and cropping the acquired image, among others. Most image processing systems scale the initial acquired image to a fixed resolution to maximize storage capacity or minimize computing strain. Because the image was captured in the field, it is unavoidable that some droplets, insect excretes, and dust will appear on the captured images. These are referred to as picture noises in image processing. They must be eliminated before any further picture analysis can take place. After the image has been improved, the region of interest in the image, i.e. the diseased portion of the image, is extracted. Image segmentation can help with this. The following are detailed descriptions of the steps involved in image preprocessing:

RGB to Grayscale Converter

It is a critical component of picture processing. There are two conversion methods accessible in this technique: the average approach and the weighted method. However, the average approach is simpler than the weighted method because it takes the average of the three colors (red, green, and blue). To obtain an average, these colours are summed and divided by three (Eq 1).

$$Grayscale = \frac{R+G+B}{3} \qquad (1)$$

Although the average method is the simplest way for conversion, it produces a black image rather than a grayscale image. We are unable to inspect the fruit quality in this case. To address this issue, the weighted technique is used, which is more advantageous than the average. The contribution of the colours (Red, Green, and Blue) is changed correspondingly in this process to obtain an inspectable image because red has a more comparable wavelength to green and blue. Not only does green have a shorter wavelength than red, but it also has a good smoothing impact on the eyes. In this situation, the contribution of these colors must be adjusted. Reducing the contribution of red colour, boosting green colour, and modifying blue in between creates an excellent grayscale image. The following is the equation for the same:

$$Grayscale = \big((0.3 \times R) + (0.59 \times G) + (0.11 \times B)\big) \qquad (2)$$

Image Filtering

As previously stated, the acquired image contains a high level of noise, which limits the software's detection and identification capabilities. Image filtration techniques such as high pass and low pass filters, as well as the median filter, are used to reduce noise.

Crop Image

Background noises, such as an unclear or uneven background, might be found in the acquired image. In this scenario, we must delete the undesirable portion of the image and concentrate solely on the required portion.

Image Resizing

It is critical to satisfy the needed size and form of the image for the analysis while processing the acquired image. To meet the size requirement criterion, the image should be scaled before proceeding. Typically, the resolution of the acquired image is more than 2000 2000. With the existing processing power, an image of this greater quality would be too huge to send to a CNN. In terms of file processing costs, better resolution leads to a cost increment process. The image was enlarged into standard format 400 400 after RGB to grey conversion for greater resolution.

Image Post-Processing

The use of diverse approaches, such as image processing software and algorithms, to modify the reconstructed images shown for viewing and interpretation. It primarily consists of two post-processing components: segmentation and feature extraction.

Segmentation

This is the process of separating an object from its surroundings. The initial phase of picture recognition, explanation, and categorization in image post-processing is segmentation. Similarity detection and discontinuity detection in segmentation is accomplished using two basic approaches: region-based and boundary-based methods, respectively. These two approaches are tied to the region's boundaries. For disease identification and gradation of the acquired image of the fruit, three basic segmentation procedures are used: thresholding, edge detection, and region-based segmentation. Setting a threshold value to differentiate an object from the background in an image is the threshold technique. Any pixel values more than the threshold is considered part of the object, whereas any pixel value less than the threshold is considered background. The edge detection segmentation technique involves utilizing mathematical techniques to find the edges of an object in a picture. After detecting the edges, the object may be separated from the backdrop. The region-based segmentation technique includes separating a picture into multiple parts based on similarities. After identifying the zones, the object can be separated from the background.

Feature Extraction

It is a method for extracting relevant information from segmented photos, such as colour, texture, and shape aspects. Colour features, texture features, shape features, and size features are the four feature extraction approaches.

Colour Characteristics: The colour of the fruit is an important characteristic that can be extracted for gradation and disease detection. Hue, saturation, and brightness are examples of color characteristics.

Texture Features: The texture of the fruit, which includes roughness, smoothness, and patterns on the fruit surface, can be an essential aspect.

Fruit Shape: The shape of the fruit might be an essential aspect. Roundness, elongation, and symmetry are all examples of symmetry.

Fruit Size: The size of the fruit can be a key gradation element. Diameter, circumference, and volume are all examples of size characteristics.

Classification

Classification techniques are used to categorize the fruit depending on its characteristics, such as whether it is diseased or not, and which grade it belongs to. Support vector machine and CNN are two popular classification algorithms. Python offers various classification libraries, including open CV, scikit-learn, TensorFlow, and Koras.

SOME PREVIOUSLY USED LIBRARIES
OpenCV (Open Source Computer Vision)

OpenCV (Open Source Computer Vision) is a well-known open-source library for computer vision and image-processing applications. It includes a wide range of image and video analysis capabilities and algorithms, as well as object detection and tracking, feature extraction, and other features. OpenCV is written in C++ and supports several programming languages, including Python. It provides a full range of tools and functions for image manipulation and advanced operations such as filtering, edge detection, image modification, and geometric transformations. You may import and save images in multiple formats, access and edit pixel values, use numerous image processing algorithms, and execute sophisticated tasks such as object detection, face recognition, and image stitching using OpenCV in Python. It also has video processing functionality, allowing you to record and manipulate frames from video streams or files.

OpenCV is widely utilized in both academic and industrial settings. It's been used in robots, surveillance systems, augmented reality, medical imaging, and self-driving cars. The library is constantly evolving and improving, with new algorithms and features being introduced regularly.

To utilize OpenCV in Python, use package managers like pip to install it and then import it into your Python scripts. Once imported, you can use its functions and classes to conduct a wide range of image processing and computer vision tasks swiftly and successfully.

TensorFlow

TensorFlow is a Google open-source machine learning framework. It offers a full ecosystem of machine learning tools, libraries, and resources for developing and implementing machine learning models. TensorFlow is intended to be used in both research and production scenarios, and it features a flexible architecture that enables developers to construct and train many types of machine learning models.

TensorFlow's Key Characteristics *Include*

TensorFlow employs a dataflow graph to express computations as a set of nodes linked by edges. To utilize OpenCV in Python, use package managers like pip to install it and then import it into your Python scripts. Once imported, you may use its functions and classes to accomplish a variety of image-processing tasks. The graph supports efficient parallel execution and automated differentiation for gradient-based optimization.

Deep Learning Support

TensorFlow provides significant deep learning capabilities, including a high-level API called Keras that streamlines the process of designing neural networks. It also provides

pre-built deep learning layers, optimizers, and loss functions.

Flexibility: TensorFlow provides versatility in terms of programming languages. While it is largely implemented in Python, APIs for other languages including C++, Java, and Go are provided, letting developers use TensorFlow in their language.

Distributed Computing: Tensor Flow allows for distributed computation over numerous machines, enabling the training of large-scale models. It includes management tools for distributed training, such as parameter servers and distributed sessions.

Model Deployment: TensorFlow allows learned models to be deployed in a variety of settings, including mobile devices, web browsers, and cloud platforms. TensorFlow Serving is used to serve models in production, while TensorFlow Lite is used to deploy models on mobile and embedded devices.

Community and Ecosystem: TensorFlow has a big and active community, which contributes to its diverse environment. There are a plethora of pre-trained models, libraries, and resources available to developers, making it easier for them to leverage existing solutions. It's worth noting that TensorFlow 2.0 improved and simplified previous versions, making it more user-friendly and accessible. It is still one of the most popular machine-learning frameworks in both academia and industry.

BLOCK DIAGRAM AND EXPLANATION

Web Socket: It is a computer communication protocol that allows for full duplex communication channels to be established on top of a single TCP connection. It delivers the collected image to the web socket server via the internet using a camera. Python is a general-purpose programming language with a high level of abstraction. The installation of the open-source computer vision library (OpenCV) is necessary for the applications of the general-purpose programming language, Python. OpenCV was created in 1999 by a group of dedicated coders to integrate image processing into a wide range of programming languages. It supports a wide range of operating systems, including Windows, Android, Linux, and Mac, and offers C++, C, and Python interfaces. A fruit identification technique is utilized on the Python web framework to detect and identify the fruit.

A fruit identification algorithm is utilized on the Python web framework to detect and identify fruits and diseases. Additional databases are used to return findings to the farmer. Fig. 3 depicts the procedures involved in using Python to recognize and identify images of fruits and diseases.
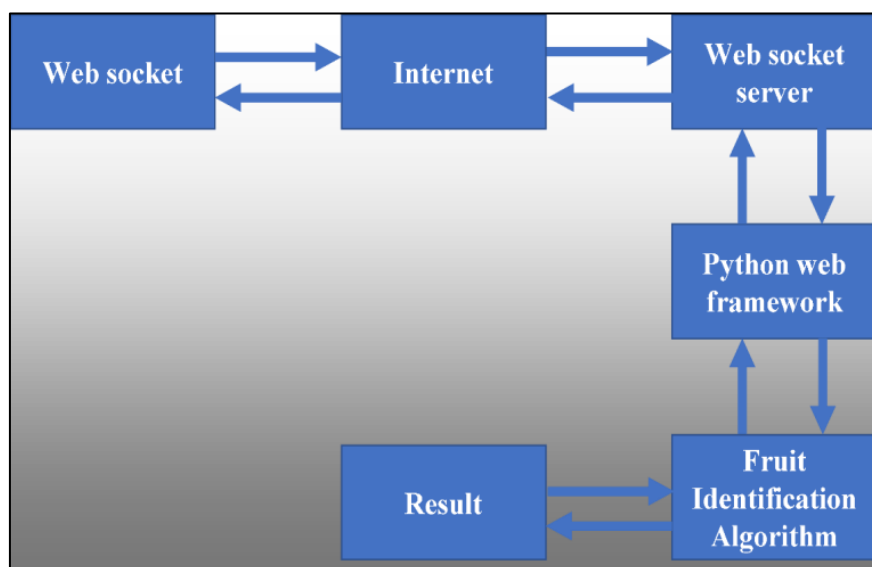
Figure 3: Fruit classification working system general approach.

The algorithm used in grading and detecting systems can be observed in Fig. 4.

The K-mean Algorithm

The K-means algorithm is a clustering

technique that iteratively divides a given dataset into K separate clusters. The K-means method is explained in detail below:

Initialization

- To determine the number of clusters you want to build, K.
- In the feature space, randomly initialize K cluster centroids.

Assignment

- Calculate the distance to each centroid for each data point using a distance metric (usually Euclidean distance).
- Assign each data point to the cluster whose centroid is closest to it.

Recalculation

- Recalculate the centroid for each cluster by averaging all data points assigned to that cluster.
- Repeat steps (as in Assignment) until the convergence requirements are satisfied. Convergence happens when the centroids no longer vary considerably or when the maximum number of iterations has been reached.

Outcome

- When the cluster centroids stabilize, the method converges.
- One of the K clusters is assigned to each data point.
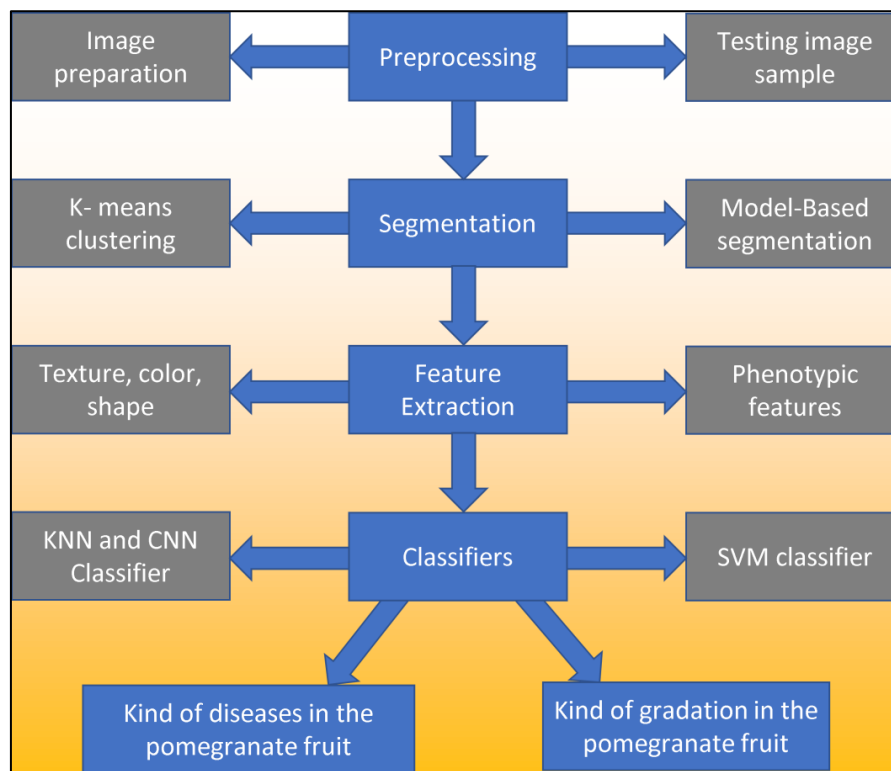
Figure 4: Algorithm used in the system.

CNN Algorithm for Fruit Gradation
Follow these procedures to grade fruits using a Convolutional Neural Network (CNN) algorithm:

Dataset Preparation

Gather a labelled dataset of fruit photos with appropriate quality grades. Divide the dataset into training and testing sets.

Data Preprocessing

Resize all of the fruit photos to a consistent scale suited for the CNN model. Normalize the image pixel values to a common scale (e.g., between 0 and 1). If necessary, augment the dataset by implementing modifications such as rotation, scaling, or flipping to expand its size and improve the

model's generalization.

Model Architecture

Create a CNN model for fruit grading. A CNN is typically composed of convolutional layers, pooling layers, and fully linked layers. Based on the features of the fruit photos and the grading objective, select the appropriate number and size of filters, activation functions, and pooling processes.

Evaluation

Assess the trained model's performance on the testing dataset.
To assess the model's success in fruit grading, compute measures such as accuracy, precision, recall, or F1 score.

Prediction

Use the learned CNN model to forecast the quality of new, previously unseen fruit photos. The input fruit image should be preprocessed in the same way as the training

images (resize, normalize). To acquire the anticipated quality grade, run the preprocessed image through the trained CNN model. Using deep learning packages such as TensorFlow or PyTorch to create a CNN model for fruit grading in Python is common. The following is a general summary of the steps involved:

Using the deep learning library of choice, define the CNN architecture. The fruit image dataset should be preprocessed (resized, normalized, and augmented). Divide the dataset into two parts: training and testing. Compile the CNN model with the loss function, optimizer, and evaluation metric specified using the training dataset, and train the CNN model. On the testing dataset, evaluate the model's performance. Predict the quality grade for new fruit photos using the training model. The specific implementation details and code can vary depending on the chosen library and the specific requirements of your fruit grading task. It's important to refer to the documentation and examples provided by the respective deep learning library for more specific guidance on building and training a CNN model for fruit grading (Fig. 5).
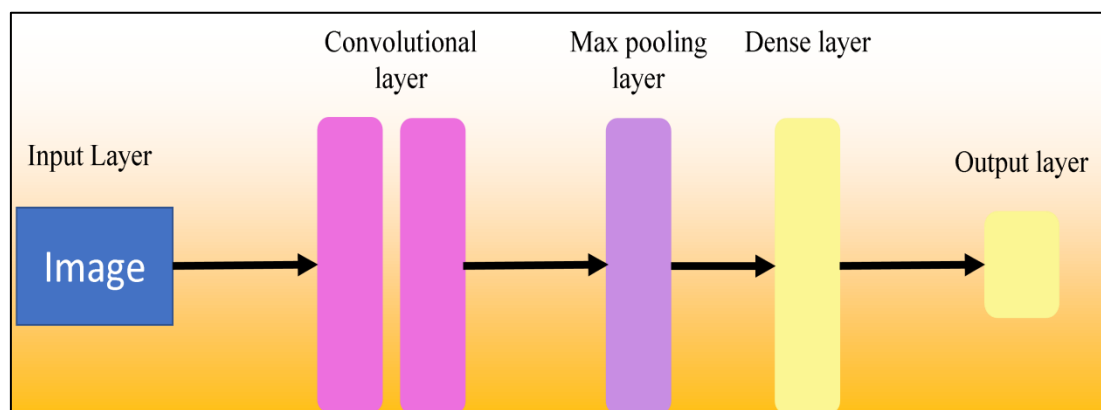
Figure 5: CNN architecture.

RESULTS AND DISCUSSION

Image acquired by the camera, then the image of the pomegranate used as input image is segmented and resized by some function. The image is then enhanced using a contrast-enhanced approach.
Python, a high-level programming language, is used to test the suggested working system. It features a large ecosystem of libraries and frameworks dedicated to scientific computing, machine learning, and image processing. TensorFlow, Keras, PyTorch, and scikit-learn

libraries provide strong tools and functionality for quickly building and training machine learning models. OpenCV and sci-kit-image are two good image-processing packages in Python. This library includes a wide range of functionalities for picture segmentation and feature extraction in the detection of fruit illnesses.

To detect the three diseases and normal (non-infected) fruit features such as the number of fruit spots, fruit colour, fruit shape, and fruit size are carefully recorded. 75% of the total dataset obtained was utilized as training data,

while the remaining 25% was used as testing data. The CNN model produced four classes (infected/uninfected), with a classification test accuracy of 0.333333432674408 and a test loss of 0.8594796061.

Premises

Our research is divided into four categories (Table 4). We have a dataset with four labels: (1) Bacterial blight, (2) Fruit Rot, (3) Alternation fruit spot, and (4) Non-infected.
True Positive (TP) - The number of samples

accurately recognized as having a specific condition.
False Positive (FP) - The number of samples wrongly recognized as having a specific condition.
True Negative (TN) - The number of samples successfully recognized as not having the specified illnesses.
False Negative (FN) - The number of samples wrongly recognized as not having the specified illnesses.

Table 4: *Each disease has a positive instance and a negative instance.*

Disease Name	TP	FP	TN	FN
Bacterial Blight	20	5	70	5
Fruit Rot	40	10	95	5
Alternaria Fruit Spot	72	8	100	20
Non-Infected	25	20	85	12

Precision is a performance indicator that is often used in classification tasks, such as detecting illnesses in pomegranate fruit. It calculates the fraction of accurately predicted positive instances (True Positive) out of all positive instances anticipated. Precision is used to assess the accuracy of a model's positive predictions.
Precision is computed mathematically as per Eq 3

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive} \quad (3)$$

Sensitivity: Sensitivity, often known as recall or true positive rate, is a classification task performance indicator that measures the proportion of properly predicted positive cases (true positives + False Negatives). The model's sensitivity measures its ability to correctly identify positive cases.
Sensitivity can be computed mathematically as per Eq 4

$$Sensitivity = \frac{True\ Positive}{True\ Positive + False\ Negative} \quad (4)$$

Detection accuracy: Detection accuracy is a performance indicator that is widely used to assess a classification mode's overall efficacy in correctly anticipating the class labels of a dataset. It calculates the percentage of correctly classified

instances (True Positive + True Negative) concerning the total number of instances. Accuracy is computed mathematically as per Eq 5

$$Accuracy = \frac{True\ Positive + True\ Negative}{Total\ Instances} \quad (5)$$

In the detection of pomegranate fruit disease, accuracy measures the model's ability to properly categorize both infected and uninfected fruits. A high accuracy score implies that the model distinguishes between infected and non-infected fruits well.
The F1 score is a performance metric that combines precision and recalls into one result. It provides a balanced assessment of a model's accuracy by taking into account both the capacity to correctly identify precision and the ability to capture all recall or sensitivity.
The F1 score is calculated mathematically as (Eq 6) the harmonic mean of precision and recall:

$$F1\ score = \frac{2 \times (Precision \times Recall)}{Precision + Recall} \quad (6)$$

The F1 score is a number between 0 and 1, with 1 representing flawless precision and recall. A higher F1 score suggests a better balance of precision and recall, indicating a more accurate

and dependable model. The F1 score evaluates the model's ability to properly classify damaged fruits while minimizing false positives and false negatives in pomegranate fruit disease detection. It takes into account both precision and recall. A comparison of precision, recall, and F1 scores is represented in Table 6.

Matrix of Confusion

The structure of the confusion matrix can be seen at below-mentioned Table 5.

Table 5: Confusion matrix structure.

	Actual value		
		P	N
Predicted value P		TP	FP
N		FN	TN

TP-True Positive, FP-False Positive, FN-False Negative, TN-True Negative

Table 6: Comparison between precision, recall & score.

Diseases Label	Precision	Recall	F1-Scope
1	0.80	0.80	0.80
2	0.80	0.89	0.84
3	0.90	0.75	0.83
4	0.55	0.67	0.60

Further, I have taken multiple readings for disease detection. It is seen that the accuracy of the CNN model is ~0.8586.

CONCLUSION

Using image processing and the Python programming language, we are improving the grading and illness detection of Pomegranate fruits. Python, a high-level programming language, is used to test the suggested working system. It features a large ecosystem of libraries and frameworks dedicated to scientific computing, machine learning, and image processing. TensorFlow, Keras, PyTorch, and scikit-learn libraries provide strong tools and functionality for quickly building and training machine learning models. OpenCV and sci-kit-image are two good image-processing packages in Python. In the fruit grading process, computer vision and image processing algorithms produce non-destructive and accurate results. Image segmentation, feature extraction, and other approaches are used to identify diseases and improve fruit grading. Depending on the characteristic, each offers pros and downsides. This finally helps farmers in their everyday battle against disease outbreaks. Once the diseases have been correctly recognized, farmers can treat them with the assistance of experts. The CNN model is also used to detect and grade diseases. Overall, using a CNN model to detect and grade pomegranate fruit illness gives a strong and efficient strategy for improving harvesting management practices. Its capacity to reliably detect problems, give gradation, and enable decision-making will help pomegranate enterprises boost output, minimize losses, and practice sustainable agriculture.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENT

REFERENCES

1. Lee, Y. Chang, J. K. Archibald, and C.

G. Greco, "Color quantization and image analysis for automated fruit quality evaluation," *4th IEEE Conf. Autom. Sci. Eng. CASE 2008*, pp. 194–199, 2008, doi: 10.1109/COASE.2008.4626418.

2. Kumar R, V. S. Rajpurohit, and K. Y. Bidari, "Multi Class Grading and Quality Assessment of Pomegranate Fruits Based on Physical and Visual Parameters," *Int. J. Fruit Sci.*, vol. 19, no. 4, pp. 372–396, 2019, doi: 10.1080/15538362.2018.1552230

3. D. Sreenivasulu, J. Sirishadevi, P. Arulprakash and S Venkataramana (2022). Implementation of latest machine learning approaches for students' grade prediction, *International Journal of Early Childhood Special Education*, 14(3), 9887-9894, Available at: https://www.researchgate.net/publication/36 2568207_Implementation_of_Latest_Machi ne_Learning_Approaches_for_Students_Gr ade_Prediction.

4. R Aavula, A Deshmukh, V A Mane and Gajanan H Chavhan (2022), "Design and implementation of sensor and IoT based remembrance system for closed one", [Online] Available at: https://www.researchgate.net/publication/36 2694181_Design_and_Implementation_of_ Sensor_and_IoT_based_Remembrance_Sys tem_for_closed_one [Accessed on August 2022].

5. U. M. Halli, V Kazi and S Kazi (2023). Deep learning, YOLO and RFID based smart billing handcart, *Journal of Communication Engineering & Systems*, 13(1), 1-8, Available at: https://computerjournals.stmjournals.in/inde x.php/JoCES/article/view/1020.

CITE THIS ARTICLE