An Automated Approach for Pomegranate Disease Detection using Image Processing and SVM

Vanita S. Lokare[1], Dr. P.P. Belagali[2]

[1] P. G. Student / Department of Electronics and Telecommunication Engineering / Dr. J.J.M.C.O.E. Jaysingpur, Shivaji University, Kolhapur, India

[2] Associate Professor/ Department of Electronics and Telecommunication Engineering / Dr. J.J.M.C.O.E. Jaysingpur, Shivaji University, Kolhapur, India

Corresponding Author Email: lokarevanita91@gmail.com

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Abstract—

Pomegranate is an important fruit crop with high nutritional and economic value. However, its production is significantly affected by diseases such as bacterial blight, anthracnose, fruit rot, and leaf spot. These diseases reduce both the quality and quantity of the produce, leading to economic losses for farmers. Early detection is therefore essential to control their spread and improve productivity. Traditional methods rely on manual inspection, which is time-consuming, labor-intensive, and often less accurate. This study presents an automated system for detecting pomegranate disease using image processing and machine learning. The main objective is to develop an efficient and accurate method for identifying diseases in fruits and leaves at an early stage, while ensuring the system remains simple and practical for farmers. The proposed system includes four main stages: preprocessing, segmentation, feature extraction, and classification. In preprocessing, images are resized and enhanced to improve quality and remove noise. Segmentation is performed using K-means clustering to separate infected regions from healthy areas. In the feature extraction stage, key features such as color, texture, and shape are obtained from the images. These features are then used in the classification stage, where a Support Vector Machine (SVM) classifier is applied to distinguish between healthy and diseased samples. The system is trained and tested on a dataset of pomegranate fruit and leaf images, achieving high accuracy in disease detection. This demonstrates the effectiveness and reliability of the proposed approach. Overall, the developed system offers a fast, accurate, and practical solution for early disease detection in pomegranate crops. It helps reduce crop losses, improve yield quality, and supports the adoption of smart and sustainable agricultural practices.

Keywords— Pomegranate; Image processing; SVM; Bacterial blight; leaf spot.

I. INTRODUCTION

Pomegranate is a widely cultivated fruit crop valued for its high nutritional, medicinal, and economic importance. It is rich in antioxidants, vitamins, and bioactive compounds, making it beneficial for human health. In countries like India, pomegranate cultivation contributes significantly to the agricultural economy. However, its productivity and quality are severely affected by diseases such as bacterial blight, anthracnose, fruit rot, and leaf spot, resulting in significant yield losses and reduced market value [1,2].

Early and accurate detection of plant diseases is essential for effective crop management and minimizing economic losses. Traditional disease detection methods rely on visual inspection by farmers or experts, which is time-consuming, labor-intensive, and often subjective. These limitations can result in delayed diagnosis and improper treatment [3]. Moreover, the lack of expert availability in rural areas underscores the need for automated, reliable detection systems. With advancements in image processing and machine learning, automated plant disease detection has become an active area of research. Image processing techniques enable the analysis of visual symptoms such as color changes, texture variations, and shape distortions in infected plant parts. When combined with machine learning algorithms, these methods can achieve high accuracy in disease classification [4,5]. Such systems can assist farmers in timely decision-making and reduce dependency on manual inspection.

In this paper, an automated system for pomegranate disease detection is proposed using image processing and machine learning techniques. The system includes stages such as image preprocessing, segmentation, feature extraction, and classification. Preprocessing enhances image quality, while segmentation (using K-means clustering) isolates infected regions. Feature extraction captures important characteristics such as color, texture, and shape, which are then used by a Support Vector Machine (SVM) classifier to identify diseases. SVM is widely used due to its robustness and effectiveness in classification problems [6]. Furthermore, the integration of such automated systems with modern technologies like mobile applications and IoT-based monitoring can significantly enhance their practical applicability in real-time agricultural scenarios. Farmers can capture images of crops using smartphones and obtain instant disease diagnosis, enabling quick decision-making and timely treatment. This not only reduces dependency on expert consultation but also promotes precision agriculture practices. Therefore, the proposed system has the potential to bridge the gap between advanced computational techniques and field-level farming, contributing to improved crop management and sustainable agricultural development.

The proposed approach aims to provide a simple, efficient, and accurate solution for early disease detection in pomegranate crops. By enabling timely intervention, the system can help reduce crop losses, improve yield quality, and support the adoption of smart and sustainable agricultural practices.

II. LITERATURE REVIEW

H. Wang et al [7] showed that digital image-based plant disease detection can reduce the need for expert knowledge in agriculture. It helps in making plant protection more automated and efficient. The study uses four types of neural networks such as BP, RBF, GRNN, and PNN for disease classification. Different features like color, shape, and texture are extracted from the images. These features are used to distinguish between similar plant diseases. The results show that neural networks can effectively identify and classify plant diseases. An automatic grading of diseases in pomegranate leaves using image processing techniques is showed a promising result in pomegranate plant disease detection and classification.

The research described by Akhilesh et al. in [8] deals with a design of computer system to automatically identify and classify pomegranate diseases using advanced digital image processing. To reduce the financial losses faced by farmers, the authors of the present system developed a system using a workflow, image pre-processing, and Grab cut segmentation to distinguish the infected areas of the fruit from the background. This system works by using the feature extraction technique, focusing on the color features and the Canny edge detection technique, to identify the severity of the diseases and the types of infections using the number of pixels. By identifying diseases such as bacterial blight, borer, and cercospora, the system provides agriculturalists with immediate preventive and treatment options. This system acts as a cost-effective and efficient way to monitor the health of the crops, aiming to improve the productivity of the crops.

Patil et al.[9] reviewed modern image processing techniques for detecting pomegranate fruit diseases. The study focuses on methods used to diagnose and classify that lead to significant agricultural losses.The authors propose a process that commences with digital image acquisition, followed by preprocessing to remove noise, and segmentation techniques like K-means clustering to extract infected regions. In this process, certain morphological features can be used to apply classification algorithms like SVM to forecast diverse fungal and bacterial infections with substantial precision. Despite achieving accuracy rates of up to 99% , the review points to the pressing need to develop standardized datasets and fully automated systems to assist farmers. In essence, the author asserts that replacing manual inspection with soft computing can improve crop yield and stabilize the agricultural economy.

The academic review presented by Deshpande et al. [10] discusses the current technological approaches to detect diseases in pomegranates, which is an important area to be addressed for the sustained growth of the crop and the profitability of farmers. The authors highlight that though the traditional method of inspection is no longer effective, Artificial Intelligence approaches such as Convolutional Neural Networks (CNN) and Digital Image Processing are effective tools to detect diseases such as bacterial blight and anthracnose with high accuracy. The review, based on the analysis of various academic research works, reveals that though deep learning approaches can result in accuracy levels higher than 97%, the major problem lies in the need for a variety of images to be obtained under unpredictable conditions.

Kantale et al. [11] presented a detailed review of machine learning and image processing techniques. The study focuses on identifying and classifying different pomegranate diseases. It includes major diseases such as bacterial blight and fruit rot. The paper shows how these techniques help in accurate disease detection. The authors point out that the process is often too time-consuming and difficult for the farmer to diagnose manually, which is why the use of computer-automated recognition is vital to the preservation of the agricultural industry. By considering many technical approaches to the process, the authors describe how a standard process is used to segment the affected area of the fruit, then use feature extraction techniques to identify the unique characteristics of the diseases, and finally use classification techniques such as the Support Vector Machine and the Artificial Neural Network. This paper is a technical overview and a literature review that shows how advanced computer techniques can achieve high levels of accuracy.

In conclusion, the literature survey reveals that significant research has been conducted in the field of plant disease detection using image processing, machine learning, and deep learning techniques. These approaches have demonstrated promising results in improving the accuracy and efficiency of disease identification. However, several challenges still remain. Issues such as limited and imbalanced datasets, variations in environmental conditions (e.g., lighting, background noise, and image quality), and the lack of robust real-time systems continue to affect overall performance and reliability. Additionally, many existing models are developed under controlled conditions and may not generalize well to real-field environments. There is also a need for lightweight and cost-effective solutions that can be easily deployed on mobile or edge devices for practical use by farmers. Future research should focus on developing more generalized, scalable, and user-friendly systems by incorporating larger and diverse datasets, advanced algorithms, and real-time implementation strategies. Addressing these challenges will further enhance the effectiveness of automated plant disease detection systems and contribute to the advancement of precision and sustainable agriculture.

III. METHODOLOGY

The proposed methodology for pomegranate disease detection integrates image processing and machine learning techniques to develop an accurate and automated system. The workflow consists of dataset preparation, image acquisition, preprocessing, segmentation, feature extraction using GLCM, and classification using SVM. Each stage contributes to improving the reliability and performance of the system.

3.1 Dataset Preparation: A comprehensive dataset of pomegranate fruit and leaf images is prepared, including both healthy and diseased samples such as bacterial blight, anthracnose, fruit rot, and leaf spot. Images are collected from real field conditions using smartphones or digital cameras, as well as from publicly available datasets. Proper labeling of images is performed to ensure correct classification. The dataset is then divided into training and testing sets (e.g., 70:30 split) to evaluate model performance effectively.

3.2 Proposed Methodology:

3.2.1 Image Acquisition: Images of pomegranate fruits and leaves are captured under natural environmental conditions. These images may include variations in lighting, background, and orientation, which help make the model robust for real-time applications.

3.2.2 Image Preprocessing: The acquired images are preprocessed to enhance quality and remove noise. This step includes resizing images to a standard size, applying filters such as median filtering, and converting images from RGB to HSV color space. Preprocessing improves contrast and highlights important features, making further analysis more effective.

3.2.3 Image Segmentation: Segmentation is used to isolate the diseased regions from healthy portions of the image. K-means clustering is applied to group pixels based on color similarity. This step helps in identifying the Region of Interest (ROI), which contains the infected areas for further processing.

3.2.4 GLCM Feature Extraction: (Texture Analysis) After segmentation, texture features are extracted using the Gray Level Co-occurrence Matrix (GLCM). GLCM analyzes the spatial relationship between pixel intensities and extracts features such as contrast, correlation, energy, and homogeneity. These features are crucial for distinguishing between healthy and diseased regions, as diseases significantly alter surface texture patterns.

3.2.5 Disease Classification: using SVM The extracted features (color, texture, and shape) are fed into a Support Vector Machine (SVM) classifier. SVM is chosen due to its high accuracy and strong generalization capability. It works by finding an optimal hyperplane that separates different classes. The trained model classifies input images into healthy or diseased categories.

3.3 Performance Evaluation: The performance of the proposed system is evaluated using standard metrics such as accuracy, precision, recall, and F1-score. These metrics provide a comprehensive understanding of the model's effectiveness in correctly identifying diseased samples while minimizing false predictions.

3.4 Overall Workflow: The complete workflow of the proposed system follows a sequential process starting from image acquisition to final classification, as shown in Fig.1. Each stage is interconnected and contributes to improving the accuracy and robustness of disease detection.

Overall, the proposed methodology provides a systematic, efficient, and scalable approach for early detection of pomegranate diseases. By combining image processing with machine learning techniques, the system ensures accurate classification and supports timely decision-making, ultimately contributing to improved crop yield and sustainable agricultural practices.

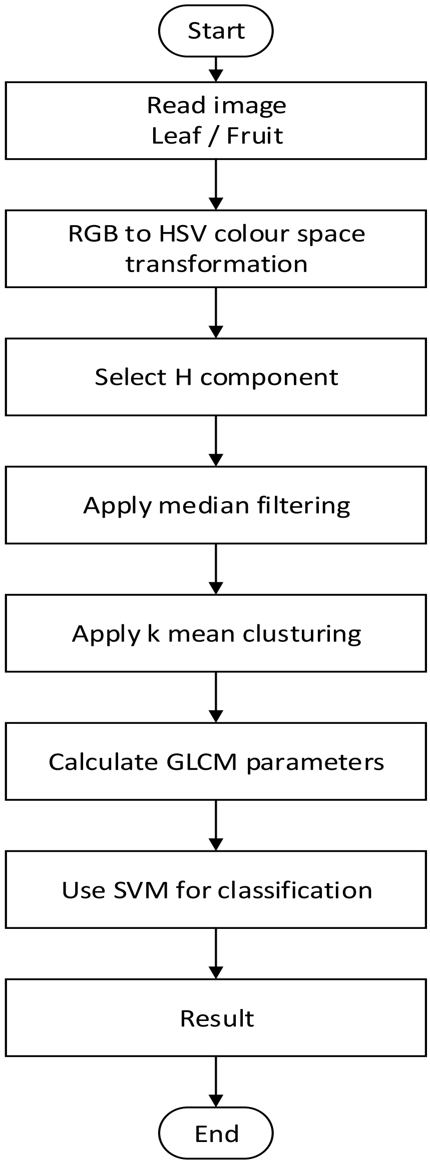

Figure 1: Workflow for disease detection

IV. RESULTS AND DISCUSSION

The developed system is designed and executed using the MATLAB platform, which provides a robust environment for implementing image processing and machine learning techniques. Its extensive set of built-in functions and toolboxes enables efficient handling of tasks such as image enhancement, segmentation, feature extraction, and classification. To further improve usability, a Graphical User Interface (GUI) is incorporated, allowing users to interact with the system in a simple and intuitive manner. During the results stage, input images undergo preprocessing to enhance clarity and reduce noise, ensuring accurate analysis. Segmentation techniques are then applied to distinctly identify and isolate diseased regions from healthy portions. Subsequently, relevant features such as color and texture are extracted, which serve as key inputs for the classification process. These features enable the model to effectively differentiate between healthy and infected samples.

The machine learning component is implemented using MATLAB tools, where the model is trained and validated on a dataset of pomegranate images. MATLAB also facilitates the visualization of outcomes through plots and performance metrics, making it easier to interpret and evaluate system accuracy. In addition, the GUI allows users to conveniently upload images and view the detection results in a clear and structured format. This enhances accessibility and ensures that the system can be effectively used by farmers and non-technical users. Overall, MATLAB provides a comprehensive and efficient framework for developing a reliable pomegranate disease detection system. Accompanying these visuals, provide concise yet comprehensive explanations that guide readers through the interpretation of the data. This includes highlighting notable trends, outlining statistical significance, and contextualizing the results within the broader research framework.

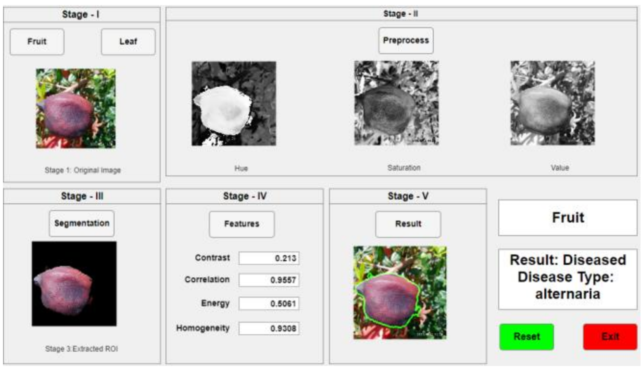

Figure 2: Final classification result for Alternaria disease

The above Fig. 2 shows the disease detection of Alternaria on pomegranate fruit using the developed model and UI interface. Similarly, Fig. 3 shows the disease detection of Anthracnose using the same technique.

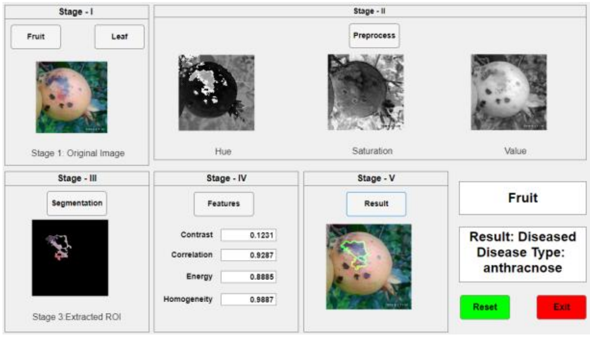

Figure 3: Final classification result for Anthracnose disease

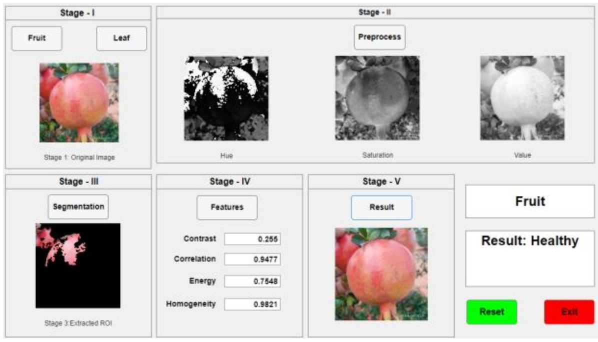

Figure 4: Final classification result for healthy fruit

V. CONCLUSION

In this study, an automated system for pomegranate disease detection was developed using image processing and machine learning techniques. The proposed approach effectively integrates preprocessing, segmentation, feature extraction, and classification to accurately identify diseases in pomegranate fruits and leaves. The use of K-means clustering for segmentation and GLCM for texture feature extraction enables precise identification of infected regions, while the Support Vector Machine (SVM) classifier ensures reliable and accurate classification. The system was implemented in the MATLAB environment and tested on a dataset of pomegranate images. The results demonstrate that the proposed method achieves high accuracy and performs efficiently in distinguishing between healthy and diseased samples. The incorporation of a user-friendly graphical interface further enhances the practical applicability of the system, making it accessible to farmers and non-technical users.

Overall, the proposed system provides a simple, cost-effective, and efficient solution for early detection of pomegranate diseases. It helps in reducing crop losses, improving yield quality, and supporting timely decision-making. This work contributes to the advancement of smart and sustainable agriculture by enabling the adoption of automated disease detection techniques.

Future improvements may include the use of larger datasets, deep learning models, and real-time deployment through mobile or IoT-based platforms for enhanced performance and scalability. abstract.

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