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Enhancing Watermelon Diseases Detection using Dense-EfficientNet and Explainable AI

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***Abstract*—Watermelon, *Citrullus lanatus*, is an edible fruit of the flowering plant species of the *Cucurbitaceae* family. This South African fruit is highly cultivated worldwide with more than 1000 varieties. Like all fruits, watermelon also has some major diseases such as Downy Mildew, Anthracnose, and Mosaic Virus which are caused by *Pseudoperonospora cubensis*, *Colletotrichum orbiculare*, and *Watermelon mosaic virus* respectively. While watermelon exportation and cultivation helps with huge economic sectors, these diseases are continuing to hold the production back, making it difficult for the farmers as well. Traditional methods for detecting these diseases are expensive, time-consuming, and require years of experience, whereas Deep learning offers promising solutions for early and accurate detection, which are cheap, less time consuming, and standard maintained procedure. Proposed deep learning model is DenseEfficient which combines the strengths of DenseNet121 and EfficientnetV2B0. DenseNet121 achieves high accuracy and efficiency by connecting each layer to every other layer, with up to 121 or 201 layers, enhancing feature reuse. Additionally, it incorporates the stability and accuracy of EfficientnetV2B0's progressive learning rate and advanced neural architecture search to enhance the image recognition tasks. Image Resize, Color inversion Image Augmentation and Outlier handling has been used as pre-processing techniques. In this study, the dataset had 1,115 images of five different classes of watermelon. Using the DenseEfficient model, the generated accuracy was 98.45% where the precision, recall, and F1-score were 0.9993, 0.9981, and 0.9991 respectively. These results inform that DenseEfficient can correctly categorize watermelon diseases and due to its quick performance in classification, it can be very useful tool for increasing watermelon cultivation.**

***Index Terms*—Watermelon leaf Diseases, Densenet121, Efficientnetv2b0, Explainable AI, Deep learning, Hybrid model**

I. Introduction

Watermelon, scientifically known as *Citrullus lanatus*, is a flowering plant species of the *Cucurbitaceae* family which is cultivated worldwide, with more than 1,000 varieties. In Bangladesh, during the fiscal year 2021-2022, the most cultivated places were Patuakhali, Khulna, Bhola, Noakhali, and Barguna [1].

Despite its widespread cultivation, a significant amount of watermelon is still being spoiled or damaged because of proper early detection of diseases like Downy Mildew, Anthracnose, and Mosaic Virus which are caused by *Pseudoperonospora cubensis*, fungus *Colletotrichum orbiculare*, and *Watermelon mosaic virus* respectively. These diseases cause fruit rot, leaf rugosity, fruit distortion, stem lesions, leaf spots, and chlorotic lesions on leaves that quickly develop necrotic causing crop loss due to their quick spread, which lowers the fruit's overall quality and marketability [2]–[4].

Traditionally, external attributes like size, color, texture, and surface defects, and interior attributes like soluble solids, sugar, acidity, sweetness, and firmness, are used to evaluate the quality of watermelon. These attributes are assessed by using methods like- visual inspection, high-performance liquid chromatography, and refractometry. But these techniques are often expensive, time-consuming, and can damage the fruit, making them less efficient for large-scale assessment [5].

Deep learning, part of the artificial intelligence (AI) spectrum, offers promising solutions for early and accurate detection of watermelon diseases. Techniques such as convolutional neural networks (CNNs) can analyze images of watermelon plants and fruits to identify disease symptoms with high precision. By leveraging deep learning models, farmers can automate disease detection, reducing the reliance on manual inspections and enabling earlier intervention to mitigate disease spread and damage [6]. In summary, the use of deep learning technology to the control of watermelon disease has the potential to completely transform agricultural methods and make them more precise, efficient, and sustainable.