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Research Article

Classification of capsicum leaf disease from a complex cluster of leaves using an improved multiple layers ShuffleNet CNN model

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Abstract
Capsicum, also known as chili pepper or bell pepper, is cultivated worldwide and holds significant economic importance as a condiment, vegetable, and medicinal plant. One of the major challenges in capsicum cultivation is the accurate identification of leaf diseases. Leaf diseases can have a detrimental effect on the quality of capsicum production, leading to substantial losses for farmers. Several machine learning (ML) algorithms and convolutional neural network (CNN) models have been developed to classify capsicum leaf diseases under controlled conditions, where leaves are uniform and backgrounds are uncomplicated. These models have achieved an average accuracy of classification. However, classifying diseases becomes relatively challenging when a diseased leaf grows alongside a cluster of other leaves. Having a reliable model that can accurately classify capsicum leaf diseases within a cluster of leaves would greatly benefit farmers. Therefore, the aim of this study was to propose a model capable of classifying capsicum leaf diseases both from a uniform background and within a complex cluster of leaves. Firstly, a dataset comprising images of diseased capsicum leaves, including discolored leaves, grey spots, and leaf curling, was acquired. Subsequently, an improved multiple-layer ShuffleNet CNN model was employed to classify the different types of capsicum leaf diseases. The proposed model demonstrated superior performance compared to existing models, achieving a classification accuracy of 99.30%. Furthermore, it was concluded that augmenting the layers of ShuffleNet, utilizing a 0.01 initial learning rate, employing 50 maximum epochs, using a minibatch size of 64, conducting 10 iterations, and incorporating 205 validation iterations all contributed to the improved ShuffleNet model's success.

Keywords
Capsicum, Leaf disease, Machine learning, Convolutional neural network, ShuffleNet.

1.Introduction
Capsicum has been intensely merged into the culture of Asians, Southeast Asians, Indians, Malaysians and Indonesians, and has even become an inextricable ingredient in the local diet in numerous gastronomies, as well as being used for medicinal purposes. It is found that in China, exigency for high-quality capsicum outnumbers supply, and the price has risen to 1.42 USD per 0.5 kg in March 2022, up from 0.79-0.95 USD in February 2022 [1]. While in India, capsicum consumption is skyrocketing due to increased demand from urban consumers; exports are also in high demand, but supply is limited due to low crop productivity [2].

Common leaf diseases in capsicum are leaf spot, rapid discolouration, mosaic, and leaf curl [4–6]. Leaf spot symptoms on capsicum are primarily circular lesions with a white centre resemble frog eyes.

This depleted output is typically caused by capsicum contagion with diseases triggered by moulds, microbes, germs, and mycoplasmas, which radically diminish possible harvests [3]. The centre of the leaf spots frequently falls out, resulting in small holes. Discoloration is characterised by an unusual yellowing of the leaf, beginning at the tips and progressing to lower leaf. Normally, the oldest capsicum leaf will turn yellow first, followed by the rest of the leaves turning light green. Leaf curling, on the other hand, refers to the improper development of the leaf, causing it to curl or become distorted. This condition may be accompanied by the presence of

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