Convolutional Neural Networks-Based Potato Leaf Disease Classification

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Keywords: Classification, Leaf Disease, Deep Learning, Potato Plant, CNN

Abstract: The potato has risen to the position of fourth most eaten staple food in the world, among many others. Additionally, the world's population is the primary driver of the dramatic increase in potato consumption. But the main reason why the crop isn't as good as it might be because of potato illnesses. Things will become much worse for the plants if the illness is misclassified and is discovered too late. Fortunately, leaf conditions may be used to identify a number of illnesses in potato plants. Thus, this study introduces a method that uses deep learning convolutional neural network architectural model to accurately diagnose the four kinds of potato plant illnesses based on leaf conditions. The experiment has shown that the deep neural network based VGG19 technique is able to produce significant results, with an average accuracy of 99.07%.

1 INTRODUCTION

Numerous countries all over the globe consider potatoes to be a fundamental component of their cuisine, and they are well-known all over the world. The term "the root of all vegetables" refers to potatoes in another context. In light of the fact that India's economy is mostly based on agriculture and that the country cultivates a wide range of crops, potatoes play an important part in our society. India follows the United States as the globe's second-biggest supplier of potatoes (Wasalwar, Bagga, et al. , 2023). Expanding potato production is the most important issue since the demand for potatoes throughout the world is always growing, and our area has to start exporting as much as it can. It is a fact that several severe illnesses that affect the leaves of potatoes, such as early blight, late blight, and others, have led to a decline in export and production throughout the course of the previous few years. The majority of these issues are brought on by the delayed detection of infections in potato plants as well as errors in the recognition of illnesses. In order to lessen the negative effects that diseases have on potato plants, it is of the utmost importance to properly and promptly identify any infections that may be present in potato plants. The activities of manual monitoring that are carried out by farmers become challenging and impracticable due to the fact that they need a significant amount of time and in-depth expertise. The identification of plant illnesses that are slower will cause the spread of diseases in plants to occur in an uncontrolled manner. Because of this, farmers are also subjected to adversity. Farmers utilize the findings of personal identification as a reference in the protection of plants that are affected by the disease. This is done without the assistance of an expert in the area of plant diseases who is guiding them. As a consequence of this, the preventative actions that farmers take may not be successful and may cause harm to their crops owing to a lack of information combined with an incorrect perception of the severity of the illness, an excessive dose, or an insufficient dosage (Sholihati, Sulistijono, et al. , 2020). The proposed study aims to provide farmers with a method that is both quick and accurate for recognizing and categorizing illnesses that affect potato plants. In this research work, CNN-based VGG19 classification technique is being proposed for the categorization of potato leaves. To summarize, the remaining parts of the paper are organized as follows: Section 2 makes reference to the body of

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Kaur, R. and Khattar, S.
Convolutional Neural Networks-Based Potato Leaf Disease Classification.
DOI: 10.5220/0013595500004664

In *Proceedings of the 3rd International Conference on Futuristic Technology (INCOFT 2025) - Volume 2*, pages 493-497
ISBN: 978-989-758-763-4

work that is associated with the classification of disease detection in potato leaf cases. In the third section, the recommended approach is discussed, and then in the fourth section, the results of the experiments and discussions are presented. In the fifth and final section, the conclusion is presented

2 LITERATURE SURVEY

Distinct agricultural issues that CNN-based deep learning models have been able to solve include the detection of weeds, the diagnosis of microbiological diseases, the identification of crop bugs, and the classification of fruits. Through the process of training the network using images of both good and sick plants, the CNN model can accurately detect plant illnesses. This section discusses the technique of diagnosing unhealthy plant leaves by analyzing their images using a CNN model (Bommala, Babu, et al. , 2023) Figure 1 depicts three distinct images of potato leaves. Joseph et al. (Joseph, Ashraf, et al. , 2022) proposed a lightweight CNN-based model for the classification of tomato leaves taken from the plant village dataset available at Kaggle. The authors have employed CNN-based architecture made by using three convolution layers and one max pooling layer. The experimental outcomes of the proposed lightweight model outperform both cutting-edge machine learning methods and pre-trained models in terms of accuracy when applied to the publicly accessible Plant Village dataset. Hylmi et al. (Hylmi and Suryani, 2022) employed an image segmentation technique and a Multi-Class Support Vector Machine to construct a system for detecting potato leaf diseases. Image segmentation output is derived from a Red Green Blue (RGB) color histogram, a Gray Level Co-occurrence Matrix (GLCM) for texture features and computations of leaf spot contours for shape features. The subsequent phase is to use a linear kernel Multi-Class Support Vector Machine (SVM) to perform the categorization. The technique developed in this work has a detection accuracy of 97.56% when applied to potato leaves.

Rusli et al. (Rusli, Meng, et al. , 2022) proposed a technique based on the K-Means clustering algorithm for performing image segmentation followed by feature extraction using GLCM. The extracted features are further given as input to the Artificial Neural Network (ANN) classifier for performing the classification of healthy and diseased potato leaves with the reported accuracy equivalent to 94%. Bonik et al. (Bonik, Akter, et al. , 2023) proposed a method that uses a sequential model based on convolutional neural networks to foresee potato leaf diseases. The experimental results revealed an accuracy equivalent to 94%. However, Cross-validation and hyper parameter optimization techniques, on the other hand, were prominently missing from a significant number of the research papers that were already available. As a result of examining the studies that have already been conducted, it is clear that there are a number of research gaps and limits that need to be addressed in order to improve the predictive capabilities of plant leaf diseases.

Figure 1: Sample Images from the dataset (from left to right) Potato Early Blight, Potato Healthy, Potato Late Blight.

3 METHODOLOGY

Figure 2, provides an illustration of the processes that are involved in the methodology that has been proposed. Data collecting, preprocessing, categorization, and performance evaluation using different metrics are among the various steps that are involved in this process.

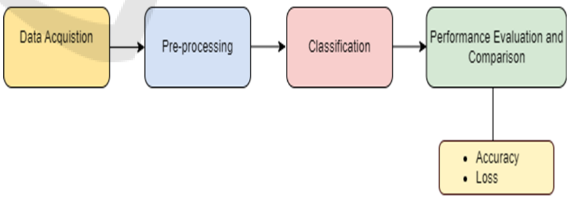

Figure 2: llustration steps involved in the methodology

3.1 Data Acquisition

The dataset that was employed in this investigation consisted of photos of potato leaves that were labeled according to three distinct categories: healthy leaves, early blight, and late blight. The authors have acquired the "PlantVillage Dataset" from the kaggle repository to conduct this work (Khattar and Verma, 2023).

3.2 Pre-processing

Here, the two primary pre-processing operations, resizing and rescaling, are put into action. Due to the large number of photographs with varying pixel sizes, all of them were resized to 256 × 256. This pre-processing step improves the model's performance by ensuring that all the input photos are of the same size. A normalization approach was used for rescaling, which separates the image's pixel values—which may be anywhere from 0 to 255 in color pictures—into the 0 to 1 range (Kaur and Juneja, 2020), (Borawar and Kaur, 2023). The suggested CNN model includes Layers including Convolution, Max or Average Pooling, and Regularization (Dropout) that must perform some computation at every level. In addition, there is a ratio of 80:10:10 between the train, validation, and test sets in the dataset.

3.3 Classification

While performing the classification task, several methods for enhancing data were applied to the training set to enhance the size of the dataset and increase its diversity, including distinct rescaling and flipping techniques. The classification model underwent training by utilizing data from the input to the output layers, which led to the formulation of predicted results and then the recognition of any mistakes or results. Back-propagation technique was employed here to adjust model weights if the predicted results came out to be inadequate and the Adam optimization technique was also utilized to enhance the classification results. During convolutional procedure, the input volume and weights were both convolutioned. Because of the stride and padding, the size of the convolved matrix can either be decreased or expanded, depending on the situation at hand. In spite of the fact that the depth grew, the spatial height and breadth decreased. Following the application of the ReLu nonlinear action function to each convolutional layer, the likelihood of the gradient vanishing was reduced, and negative values were brought down to zero. Further with the use of max pooling, the photographs were down sampled, which resulted in a reduction in overfitting, an improvement in the performance of the activation function, and a speeding up of convergence. The ultimate output layer, which was responsible for identifying a category of potato leaf pictures, was dense or completely intertwined.

4 EXPERIMENTAL RESULTS & DISCUSSION

The identification of plant leaf diseases by deep learning algorithms leads to a considerable improvement in crop output and quality. This is accomplished by reducing the biotic factors that are responsible for significant levels of agricultural production losses. The purpose of this research is to offer CNN based deep learning model that is both quick and easy, to diagnose diseases that harm potato leaves. Following the training of the models with eighty percent of the data, the Training Accuracy and Loss are computed for suggested model. After that, ten percent of the dataset was validated. A graph was created to represent the training and validation accuracy as well as the loss is shown in Figure 3.

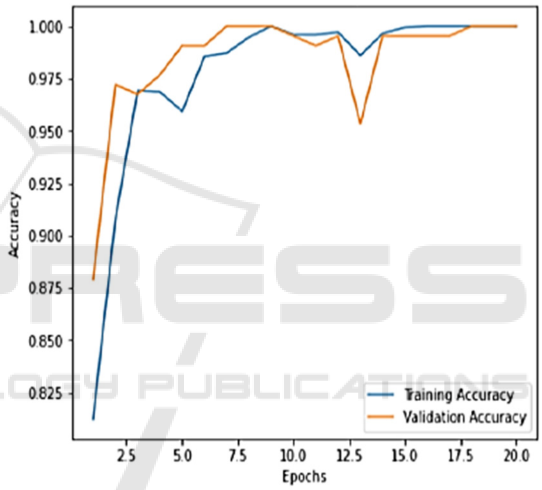

Figure 3: Training and validation Accuracy

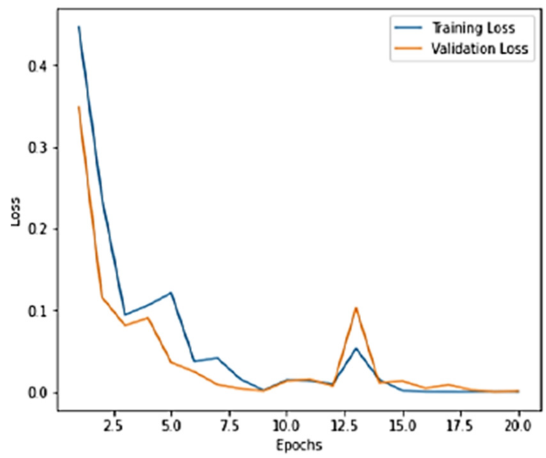

Figure 4: Training and validation loss

The ImageNet was used to train the CNN-based VGG-19, that was trained on more than one million images. With a total of nineteen layers—six convolutional, three fully connected, five MaxPool, and one SoftMax—this model is an adaptation of the VGG-16 model. A library of high-quality image representations has been built by the network. In order to classify potato leaf diseases, the experimental findings show that the suggested CNN based on the VGG19 model has low testing loss and good testing accuracy. The inference function, which was developed, received the VGG16 Trained Model as a parameter.

Table 1: Comparison with existing techniques in terms of accuracy

Sr. No	Author/ Year	Technique Used	Dataset Used	Accuracy
1	Joseph et al.[4]	CNN	Plant Village from Kaggle	98%
2	Hylmi et al., [5]	SVM with Linear Kernel	Plant Village from Kaggle	97.56%
3	Rusli et al.[6]	ANN	New plant diseases dataset from Kaggle	94%
4	Bonik et al. [7]	CNN	Plant Village from Kaggle	94.2%
5	Proposed	CNN based VGG19	Plant Village from Kaggle	99.07%

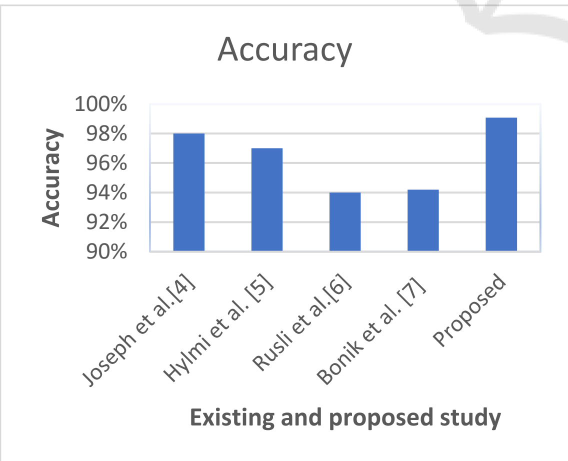

Figure 5: Barchart to show comparison with existing techniques

The system accurately identified the Potato leaf disease with a high level of certainty, using example images as input (Kaur and Juneja, 2018), (Kaur and Juneja, 2016), (Kaur and Juneja, 2021). Table 1 below shows the accuracy of the proposed method and other existing techniques. Further, Figure 4 shows the comparison of the proposed method with the existing techniques in graphical form.

5 CONCLUSIONS

This paper presents a classification approach for recognizing diseased and normal leaf images of potato plants by utilizing convolution neural network based method. When it comes to the classification of potato leaf diseases, it was shown that CNN is an effective tool. It is possible to forecast with a validation accuracy of 99% with this strategy. In general, this kind of initiative will be of utmost significance for the country's agricultural sector. The results of this study indicated that CNN gave the highest level of accuracy in comparison with other techniques for recognizing and categorizing potato leaf diseases such as early blight, late blight, and non-infected. It is possible to draw the conclusion that the techniques that are currently in use, such as personally evaluating each and every plant in a region, are both time-consuming and ineffective in comparison to the CNN methodology that is used to diagnose potato leaf diseases. This would be done with the intention of assisting the agricultural business, and farmers in particular, in recognizing and diagnosing potato plant diseases at a cheaper cost and, most importantly, in a shorter amount of time.

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