Detecting Potato Leaf Diseases with Convolutional Neural Network: A Deep Learning Approach

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ABSTRACT:

Potato blight, commonly known as early blight & late blight, is a fatal illness that damages potatoes and other Solanaceae plants. It is caused by the water fungus Phytophthora infestans and can severely harm potato crops, resulting in lower yields and economic losses. Dark spots on leaves, stems, and tubers, as well as a white fungus on the underside of leaves in moist conditions, are symptoms of potato blight. The disease is highly contagious and spreads quickly in humid and moist environments, making it difficult to treat. In our paper, we present a CNN model for disease detection in plant leaves. The model we developed is trained to examine and comprehend a diseased leaf before identifying the cause of the disease.

KEYWORDS: Potato Blight, Phytophthora infestans, CNN model.

1. INTRODUCTION:

A disorder known as a plant disease is one that interferes with or changes a plant's essential processes. The most frequent causes, which have a big impact on crop yields, include bacteria, fungi, tiny animals, and viruses. Historically, Agriculture has always been a major source of food for the mankind, with 60% of people depending on it as their main food supply. The Food and Agriculture Organization (FAO) estimates that in order to keep on top of the exponential increase in global population, agriculture's supply of food must increase by 70%. The technique of growing these crops for the highest yield and quality requires advanced technology. With the use of technology, it can be enhanced. The bulk of food is impacted by diseases of plant leaves both economic gains and losses [1]. In comparison to cereals, potatoes produce more protein, dry matter, and minerals per unit area, making them a more efficient crop. However, a number of illnesses make the production of potatoes susceptible, which can result in loss of yield as well as a decline in tuber quality, which raises the price of potatoes. Many illnesses, particularly parasite illnesses, harm potato crops, resulting in major crop production decreases and financial losses for farmers and producers [2]. Plant diseases are frequently found and identified using conventional techniques like visual inspections. However, these techniques have a number of drawbacks. They are costly since they require ongoing professional supervision and demanding since authorities are not always available locally [[11],[12]].

Economic losses and productivity decreases can be avoided and reduced by quickly identifying and classifying plant diseases. A useful method for tracking and identifying plant diseases is image analysis. Machine learning algorithms can properly classify the disease by comparing the obtained data to historical records and examining features or patterns in plant photos. Plant diseases can be recognized and categorized using a combination of image processing and machine learning techniques. In conclusion, the combination of image analysis with machine learning gives a potentially effective method for the early detection and classification of plant diseases.

2. Literature Review:

The effectiveness of multiple classifiers, including SVM, RF, and ANN for the detection of potato blight illness, was examined by Priyadarshini Patil et al. using images of leaves. Their dataset had 892 views, all of them had been reduced down to 512 * 512 before being converted into HSV images. The features that were taken out were uniformity, homogeneity, contrast, inverse difference, difference variance, and diagonality. SVM got 84% of the accuracy, ANN had 92%, and RF got 79% [3]. A method for identifying diseases from photographs of potato leaves has been described by Monzurul Islam et al. utilising a dataset of 300 photographs of potato leaves. They obscured the background and created a ROI that contained only obvious disease symptoms. They created a multiple-class SVM model after gathering statistical textual properties [3]. Md. Asif Iqbal et al. looked at 450 images of potato leaves & decreased the size of the input images to 500 * 500 pixels, converted them to HSV colored space, and then subdivided them using masks. Three feature descriptors (Hu moments Haralick Texture, and Color Histogram) were used to extract color, contour, and structure aspects, and classification was done with RF, Logistic Regression (LR), KNN, Decision Trees (DT), Naïve Bayes, LDA, and SVM classifiers [5]. Aditi Singh et al. used a dataset of 300 leaves to classify potato plant diseases. The ROI was determined using the k means method, and the GLCM features were retrieved and fed into the SVM for classification [7]. Sandika Biswas et al. utilized pictures from the Central Potato Research Institute (CPRI) with a resolution of 3000*4000 pixels to assess the severity of Potato Late Blight illness. All of the photographs were down sampled and converted to CIELAB color space. Using fuzzy c-mean (FCM) clustering, ROI and texture characteristics were obtained from each connected element. For the classification, a backpropagation neural network with three layers was utilized, with an average accuracy of 93 percent [6]. Ungsumalee Suttapakti et al. reported a potato leaf disease categorization approach based on the extraction of unique color and texture traits from 300 images. After photos were converted to L*a*b* color space, layers were divided by k-means clustering. Using the Minimum Covariance Determinant (MCD) + Conventional Kalman filter (TTF) approach, their average accuracy was 91.67% [8]. Rizqi Amaliatus Sholihati et al. classified four categories of diseases in potato plants based on leaf states using VGG16 & VGG19 deep learning convolutional neural networks and a dataset of 5,100 images. VGG-Net achieved 91% accuracy after scaling all of the images to 224*224 pixels and augmenting them [9]. Kunal Roy et al. offer a technique for diagnosing phoma blight illness using 1000 white-background potato leaflet photographs. All images were scaled to 1000*1280 pixels, converted to L*a*b color space, then divided using k-means clustering, which yielded an overall accuracy of 87% [10].

Reference	Diseases	Methods	Results
P. Patil et al.,[3]	Potato Blight Disease	Image Processing and Machine Learning using different types of Classifiers.	ANN Accuracy: 92% SVM Accuracy: 84% RF Accuracy: 79%
M. Islam et al.,[4]	Detection of Potato Diseases	Image Processing and Machine Learning using SVM (Linear)	Precision: 95% Accuracy: 95%
M.A. Iqbal et al., [5]	Potato Disease	Image Processing and ML using different typres of classifiers	LR Accuracy: 94% KNN Accuracy: 91% DT Accuracy: 91% NB Accuracy: 84% LDA Accuracy: 78% SVM Accuracy: 37%
A. Singh et al., [6]	Potato Plant Leaves Disease	Image Processing and Machine Learning using multi class SVM (Linear)	Precision: 96.12 % Recall: 96.25 % F1-score: 96.16% Accuracy: 95.99%
S. Biswas et al., [7]	Potato Late Blight Disease	Image Processing and Machine Learning using Back propagation neural network	Classification Accuracy: 93%
U. Suttapakti et al.,[8]	Potato Leaf Disease	Image Processing Techniques based Classification	Classification Accuracy: 91.67%
R. A. Sholihati et al.,[9]	Potato Leaf Disease	Image Processing and Deep Learning using CNN	Classification Accuracy: 91%
K. Roy et al.,[10]	Phoma Blight	Image Processing Techniques based Classification and Scoring using k-means.	Accuracy: 87%

Fig.1 Comparison of Literature Survey

3. Potato Disease Detection and Classification System:

Deep learning developments have taken us to the classification problem. It is also believed to be the most accurate means of dealing with plant disease detection and classification. Image processing and machine learning (ML) were initially used to identify and categorize diseases. Current advances in deep learning, which reduce the process of detection and classification while also improving accuracy, depict the block diagram of our proposed system, in which the input dataset is fed into convolutional neural networks, and after obtaining important features, the system accurately and effectively identifies the potato leaf disease.

i. **Disease Focused on**:

Early and late blight are the two most frequently occurring forms of severe illnesses observed in potato plants.

Early Blight: Early blight is a typical fungal disease that damages the leaves, stems, and fruit of tomato, potato, and other Solanaceae family species. The Alternaria solani fungus, which has a long shelf life in soil and plant waste, is the culprit.

Late Blight: The black or brown form of lesions on the leaves are known as late blight. It starts off as a little dot that expands over time and spreads across the entire plant, including the stems and fruit.

ii. CNN - A proposed Neural Network

Convolutional Neural Network is referred to as CNN. It is a particular kind of deep learning neural network that is frequently employed in tasks involving image recognition and processing. CNNs are constructed from layers of tiny interconnected processing units known as neurons and are meant to handle data that has a grid-like layout, such as photographs. These neurons manipulate the input data mathematically and send the findings to the following layer. The first layer in a standard CNN architecture conducts fundamental edge detection, and successive layers build on these features to extract ever more intricate patterns from the input data. Each neuron in the final layer corresponds to a separate class label, and the output of this layer is used to categorize the input image. In a variety of image identification tasks, such as object detection, face recognition, and image segmentation, CNNs have demonstrated to be very proficient.

iii. Dataset:

We obtained a data-set from the publicly accessible Plant Village database of Kaggle, and we categorized it as healthy, early blight, and late blight, the dataset contains of 4072 images, in which 3251 images are used for the training, 405 images for testing and 416 images are for validation.

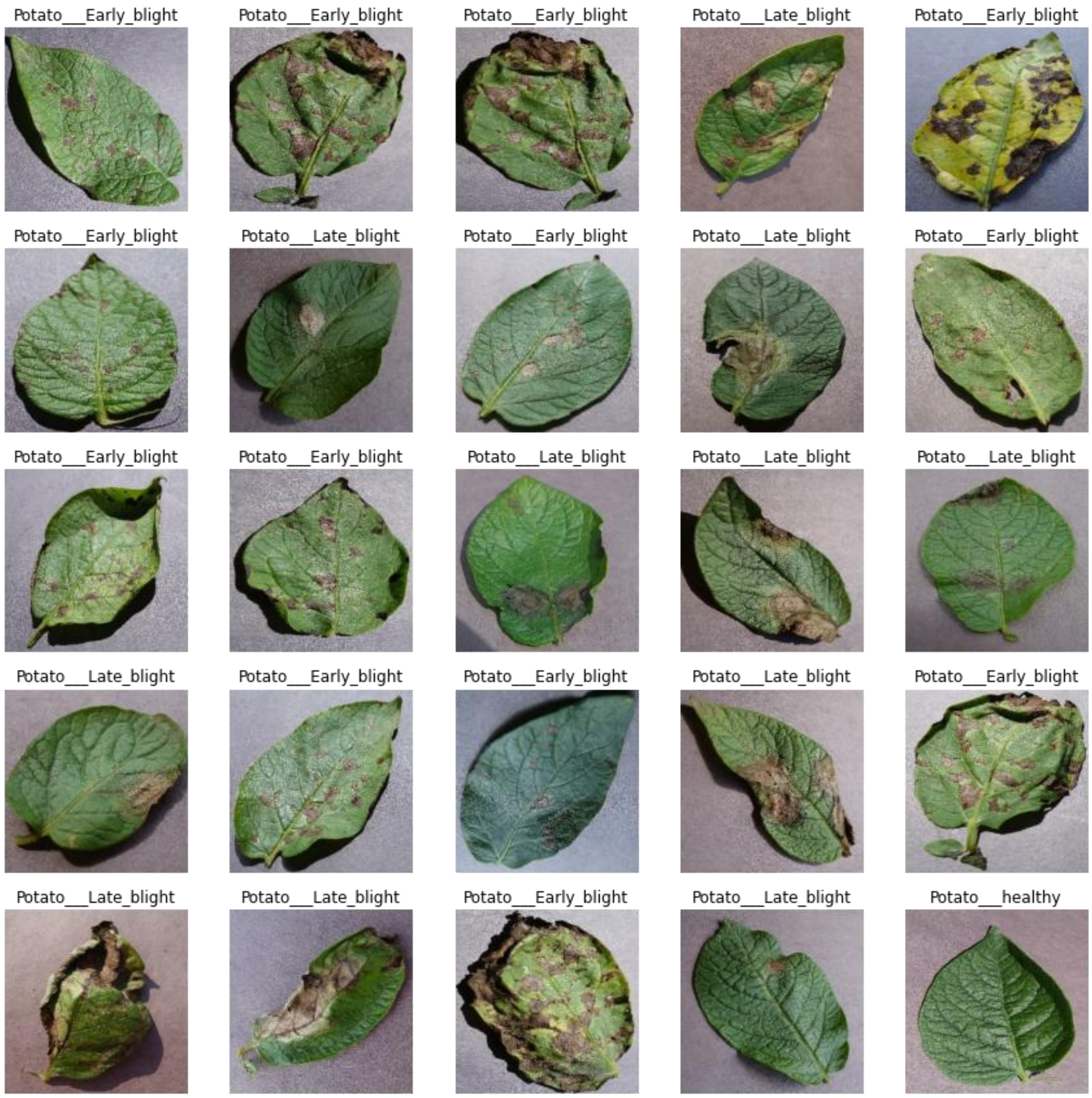


Fig.2: Sample images from the Model.

iv. Data pre-processing:

To combat over fitting and increase the variety of the dataset, several data augmentation (random rotation) approaches were used to the training set using the Image Data Generator function of the Kera's library in Python. Scale transformation (Re-scaling) was utilized to lower the computational cost by employing the same range and smaller pixel values.

v. Activation Function:

i. Rectified Linear Unit, or ReLU, is an activation function that is frequently employed in deep neural networks, especially in Convolutional Neural Networks (CNNs). The output of a neuron is transformed simply nonlinearly by the ReLU activation function. ReLU specifically leaves positive numbers alone and zeroes out all negative values. Compared to conventional activation functions like sigmoid or tanh, this non-linear activation function provides a number of advantages. First of all, as compared to other activation functions, it computes quickly. Second, adopting activation functions like sigmoid or tanh helps to solve the vanishing gradient issue that deep neural networks encounter. Finally, ReLU has been demonstrated to be an effective in application and is frequently employed in deep learning models for images. In mathematics, it can be written as:

$$x(a) = \max(0, a)$$

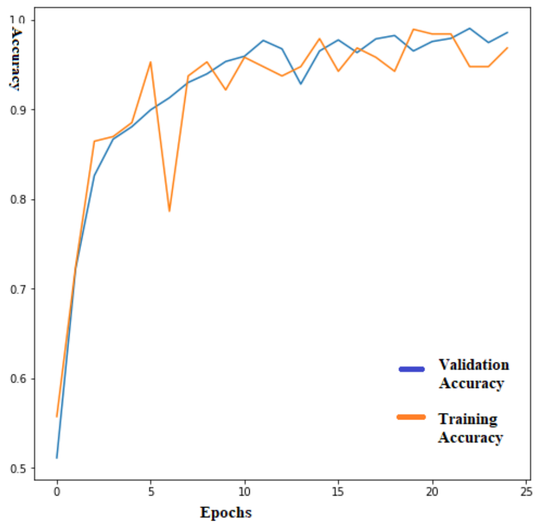
ii. In machine learning, particularly in classification problems, the mathematical function known as SoftMax is frequently utilized. A probability distribution across all conceivable classes or categories is produced by the SoftMax function given an input vector.

4. EXPERIMENTAL RESULTS:

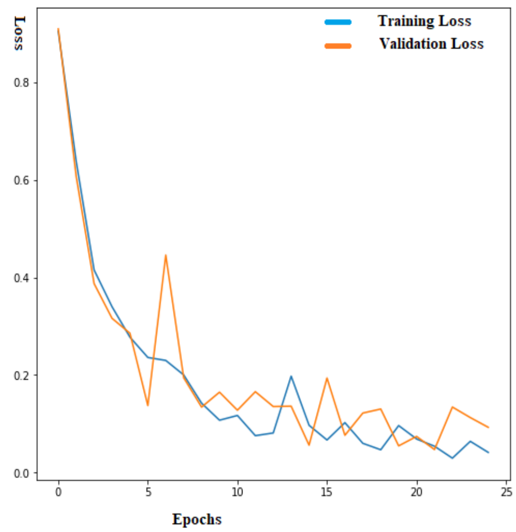
The data-set was split into 3 sets as training, testing and validation in order to determine the efficacy of the proposed work for the detection of potato leaf blight using convolutional neural network. With 22 epochs, the original dataset's average overall accuracy is determined to be 97.95%, with validation accuracy of 98.44% whereas the first epoch gave us an accuracy of 51%.

The training and testing accuracy and training and testing loss are depicted in Figs. 2 and 3, respectively. The number of epochs is indicated by the x-axis in both figures, while the accuracy and loss are shown by the y-axes in Figs. 2 and 3, respectively.

In fig.1, the comparison of literature survey, we have listed the results of the methods used to detect the potato leaf blight disease. We have got 97.95% of accuracy with validation accuracy of 98.44% by using CNN classifier for the detection of potato leaf disease.



(a) Fig.3 Training and Testing accuracy



(b) Fig.4 Training and Testing loss.

Device Configuration:

Device Name: - Desktop-K38C0FU
Processor: - Intel(R) Core (TM)i9-10900X CPU @3.70GHz 3.70GHz
Installed RAM: - 128GB (usable) Device id: - D204BDCA-5F54-498D-9856-09FC06D5BBA3
Product id: - 00330-54059-28076-AAOEM
System type: - 64-bit operating system x64-based processor

5. CONCLUSION:

Identification of plant diseases at an early stage is crucial for the agriculture sector. In this work, we try to create a CNN model to identify pathogens that cause potato blight. The model is adjusted and trained to distinguish between photos of healthy and sick potato leaves. Three classes, including the photos of healthy leaves, are present in this potato leaf image from the plant village collection. The three-color channel picture data set we utilized for the investigation was created using the enhanced approach. In the upcoming effort, a sizable number of datasets will be used to further examine the detection of potato leaf disease. We will carry out more research projects utilizing ensemble learning to assess the severity of the condition and discover improved performance.

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