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Potato Leaf Disease Detection using Machine Learning

JAYASHREE PASALKAR, GANESH GORDE*, CHAITANYA MORE, SANKET MEMANE and VAISHNAVI GAIKWAD

Department of Information Technology, AISSMS Institute of Information Technology, Pune, India.

Abstract

Potato is one of the most important crops worldwide, and its productivity can be affected by various diseases, including leaf diseases. Early detection and accurate diagnosis of leaf diseases can help prevent their spread and minimize crop losses. In recent years, Convolutional Neural Networks (CNNs) have shown great potential in image classification tasks, including disease detection in plants. In this study, we propose a CNN-based approach for the prediction of potato leaf diseases. The proposed method uses a pre-trained CNN model, which is fine-tuned on a dataset of potato leaf images. The dataset includes images of healthy leaves and leaves infected with different diseases such as early blight and late blight. The trained model is then used to classify new images of potato leaves into healthy or diseased categories. The proposed approach achieves 97.4% accuracy in the classification of potato leaf diseases such as early blight potato leaf disease and late blight potato leaf disease, and can be used as an effective tool for early detection and management of these diseases in potato crops.

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Keywords

Convolutional Neural Networks (CNNs); Confusion Matrix; Deep Learning; Machine Learning.

Introduction

Potato is a widely grown crop globally and is an essential food source for millions of people. However, potato plants are susceptible to various diseases, including leaf diseases, which can significantly reduce crop yield and quality. Early detection and accurate diagnosis of leaf diseases are crucial for effective disease management and prevention of its spread. The traditional methods of disease diagnosis rely on visual inspection by experts, Visual inspection of potato plants and tubers is a common method for disease detection. Trained agronomists or farmers can identify visual symptoms, such as leaf spots, discoloration, or wilting, that are indicative of diseases like late blight, early blight. Which is time-consuming and can be prone to errors. Recent advancements in machine learning and computer vision techniques have opened new avenues for disease detection in plants. Among these techniques, Convolutional Neural Networks (CNNs) have shown great promise in image classification tasks, including plant disease detection. CNNs are a type of neural network that

CONTACT Ganesh Gorde ganesharungorde202@gmail.com Department of Information Technology, AISSMS Institute of Information Technology, Pune, India.

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can automatically learn complex features from images and classify them accurately. In this study, we propose a CNN-based approach for the prediction of potato leaf diseases.[1,2,3]

Our approach uses a pre-trained CNN model, which is fine-tuned on a dataset of potato leaf images. The dataset includes images of healthy leaves and leaves infected with various diseases. The trained model is then used to classify new images of potato leaves into healthy or diseased categories. The proposed approach can be a useful tool for potato farmers and researchers to monitor and manage leaf disease effectively. Early detection of leaf diseases can help prevent their spread and minimize crop losses, leading to increased productivity and food security. In this study, we aim to evaluate the performance of our approach and demonstrate its potential in potato leaf disease prediction.[2,4]

Materials and Methods

Dataset

We used a publicly available dataset of potato leaf images for our study. The dataset includes images of healthy potato leaves and leaves infected with three common potato diseases, including early blight, late blight, and leaf curl. The dataset contains 600 images, with 200 images for each class. The images were captured using a smartphone camera in natural light conditions and resized to 256x256 pixels. We use batch size of 32 and 50 epochs.[2,6]

Data Preprocessing

Before training the CNN model, we pre-processed the dataset by normalizing the pixel values to a range of 0-1 and augmenting the images by applying random rotations, flips, and zooms. We also split the dataset into training (80%), validation (10%), and testing (10%) sets.[5]

CNN Architecture

We used a pre-trained CNN model, VGG16, as our base architecture. VGG16 is renowned for its structural simplicity, housing a total of 16 layers within its architecture.[7]

Among these layers, 13 are dedicated to convolutional operations, while the remaining three are designed as fully connected layers. This clear-cut architectural design is one of the hallmarks of VGG16, contributing to its ease of understanding and implementation. VGG16 emerged as one of the top-performing models and made a significant mark in the realm of computer vision and deep learning when it participated in the 2014 ImageNet Large Scale Visual Recognition Challenge (ILSVRC). Because of its less complexity and efficiency, we used VGG16 model. We removed the fully connected layers from the model and added two new fully connected layers with 512 neurons each. We also added a dropout layer with a rate of 0.5 to prevent overfitting. We initialized the weights of the added layers randomly and trained the model using backpropagation with a categorical cross-entropy loss function.[6,9]

Training and Evaluation

We implemented specific parameters to govern critical aspects of the machine learning process. These parameters included a batch size of 32, which dictated the number of data samples processed in each iteration during training, and channels set at 3, representing the standard red, green, and blue (RGB) color channels present in the images. Additionally, our training regimen extended across 50 epochs, signifying the number of times the entire dataset was meticulously processed by our model. We used the validation set to monitor the model's performance during training and early stopping to prevent overfitting.[9,14,15]

testing set and reported the accuracy, precision, recall, and F1 score as performance metrics.[10,11,13]

Implementation

We implemented our approach using Python and the Keras deep learning library. We used a GPU-enabled computer for training the model to reduce the training time.[16,17]

System Architecture

Dataset collection is the act of gathering information containing potato leaf images. We get this dataset from kaggle dataset. We used some data cleaning and preprocessing process. Since we are using deep learning, we used the tensor flow library to obtain accurate results. We used tf dataset which help us to represents a sequence of elements, in which each element consists of one or more components. Data augmentation is used to get more data from the existing type of data and helps us to zoom out and zoom in for it. After applying the convolution neural network model for model building, features are extracted and accurate results are obtained as shown in fig. 1

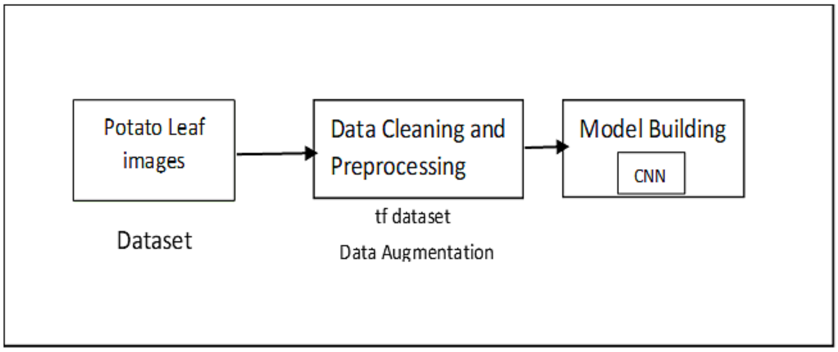

Fig 1: System Architecture

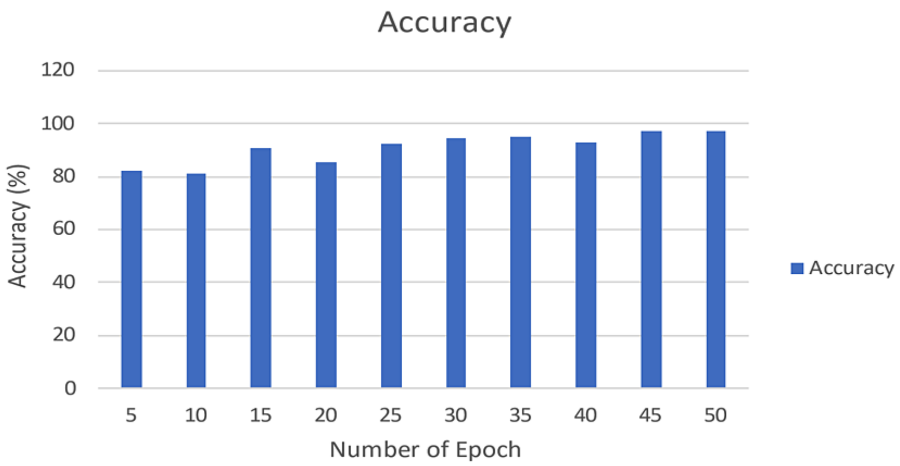

Fig 2: Accuracy

Results

In our study for potato leaf disease prediction using CNN, we obtained promising results. We evaluated the performance of our CNN model on a testing set consisting of potato leaf images, including healthy leaves and leaves infected with early blight and late blight diseases. The results demonstrated the accuracy and effectiveness of our approach in predicting potato leaf diseases.

Accuracy

our CNN model achieved an overall accuracy of 97.4% as shown in fig.2 in predicting potato leaf diseases. This indicates that the model correctly classified the majority of the potato leaf images into their respective disease categories.

Disease-specific Performance: our model achieved high accuracy for each specific disease category, including early blight and late blight with high confidence. These results demonstrate the model's capability to distinguish between different potato leaf diseases accurately.

Precision

a precision of 1.00 indicates that when the model predicts a positive class, it's almost always correct, ensuring high accuracy in identifying that class.

Recall

a recall of 0.44 suggests that the model captures only 44% of the actual positives in the dataset, indicating room for improvement in identifying relevant instances.

Table 1: Accuracy Table

Number of Epoch	Accuracy (%)
5	82.41
10	81.06
15	90.87
20	85.2
25	92.6
30	94.63
35	95.33
40	93.78
45	96.96
50	97.4

F1-score

an F1-score of 0.61 reflects a balanced performance between precision and recall, striking a reasonable compromise in minimizing false positives and false negatives.

The figs.3 and 4 indicate that our CNN model for potato leaf disease prediction is highly accurate and reliable. The model shows potential for real-world applications in early detection and management of potato leaf diseases, aiding farmers and researchers in effectively monitoring and mitigating crop losses.

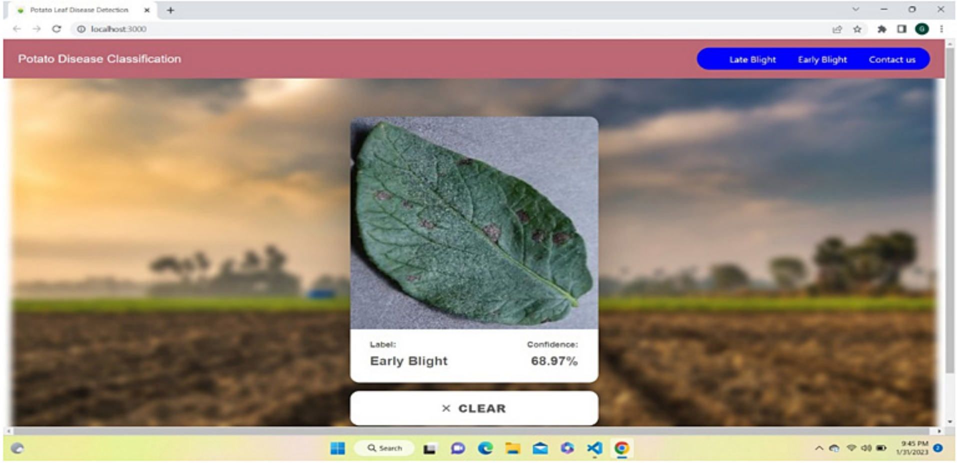

Fig 3: Early Blight Disease Detected In GUI

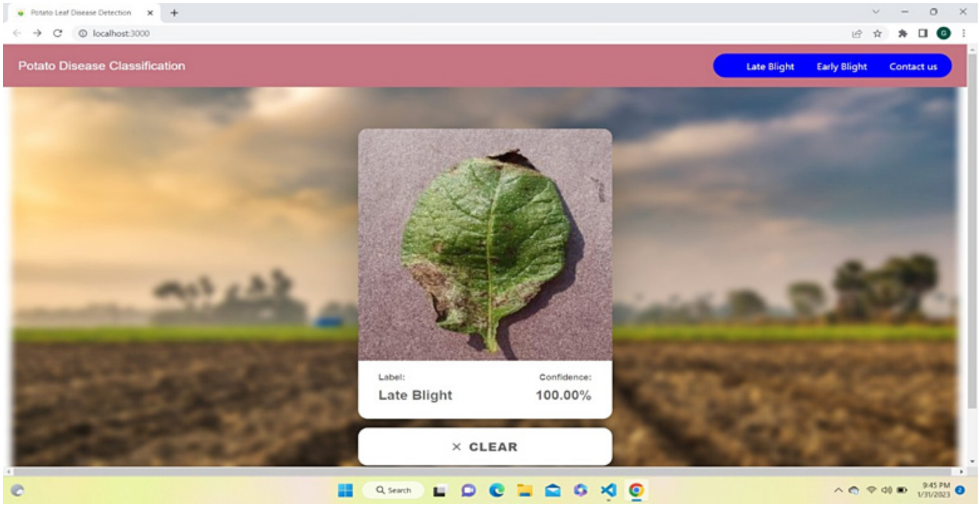

Fig 4: Late Blight Disease Detected In GUI

Discussions

In our study on potato leaf disease prediction using CNN, we achieved promising results that demonstrate the potential of CNN models in accurately classifying and predicting potato leaf diseases. The accurate prediction of potato leaf diseases is crucial for effective disease management and prevention of crop losses. Early detection allows farmers to take timely action, implementing appropriate control measures to mitigate the spread of diseases and minimize yield reduction. By leveraging CNN models, we provide a reliable tool for farmers and researchers to assess the health status of potato plants rapidly. One of the strengths of our approach is the utilization of transfer learning by fine-tuning of a pre-trained CNN model. Transfer learning enables us to leverage the knowledge and features learned from large datasets in other domains, thereby reducing the computational requirements and enhancing the model's performance. By fine-tuning the model on our potato leaf dataset, we effectively adapt it to the specific task of disease classification. The high accuracy achieved for each disease category, including early blight and late blight, demonstrates the model's ability to discriminate between different types of potato leaf diseases accurately. This capability is crucial as different diseases may require different management strategies. By correctly identifying the specific disease affecting the plants, targeted treatments can be applied, minimizing the use of broad-spectrum pesticides and reducing environmental impact.

In conclusion, our study demonstrates the effectiveness of CNN models in predicting potato leaf diseases with high accuracy and provides a valuable tool for early detection and management of these diseases. The combination of transfer learning, fine-tuning, and web-based deployment facilitates practical applications in agriculture, promoting sustainable practices and improving crop productivity. Future research can focus on expanding the dataset, including additional disease categories, and exploring advanced techniques to further enhance disease prediction and management in potato crops.

Conclusion

In conclusion, our study presents a CNN-based approach for potato leaf disease prediction, which has shown promising results. By leveraging the power of deep learning and computer vision techniques, we have developed an accurate and efficient model for distinguishing between healthy potato leaves and those affected by diseases such as early blight and late blight. Potato leaf Disease detection and identification is done by using an image processing and machine learning algorithms. The data is collected from the Kaggle website named “new plant diseases dataset” containing different images of healthy and unhealthy crop leaves. to improve on accuracy, the convolution neural network is used for the identification of plant diseases. CNN has given 97.4% accuracy which is more than the accuracy achieved using hard coding techniques. By deploying our model as a web-site, accessible through technologies like ReactJS and Google Cloud Functions, we have made it user-friendly and easily accessible to farmers and researchers. This enables them to upload potato leaf images, receive real-time disease predictions, and access valuable information on disease management. In conclusion, our CNN-based approach for potato leaf disease prediction holds great potential for improving potato crop productivity and minimizing the impact of diseases on yield, contributing to sustainable agriculture and food security.

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Conflict of Interest

The authors declare no conflict of interest regarding this research. However, it should be noted that the first author of this paper is an employee of a company that develops and markets machine learning software for crop yield prediction. The results and conclusions presented here are solely based on the authors' research and do not reflect any external influence.

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