Potato Leaf Disease Detection

Prathamesh Mandge
Information Technology
Pimpri Chinchwad College of Engineering
Pune, India
mandge.prathamesh10@gmail.com

Nilesh Morkar
Information Technology
Pimpri Chinchwad College of Engineering
Pune, India
ndmorkar@gmail.com

Pranav Narkhede
Information Technology
Pimpri Chinchwad College of Engineering
Pune, India
pranavnarkhede24@gmail.com

***Abstract*— Potatoes are a vital source of sustenance, but they face constant threats from diseases that can decimate crop yields. Machine learning, specifically convolutional neural networks (CNNs), can automate the detection process and classify diseases with exceptional accuracy.Leveraging machine learning algorithms, especially the ResNet architecture, we aim to analyze images of potato leaves and classify diseases with exceptional accuracy. This innovative approach presents great advantages over traditional methods, preferably in its automation of the detection process, thereby enhancing efficiency and facilitating earlier disease identification. This early intervention holds the potential to reduce crop losses**

Keywords-Potato leaf disease detection, CNN, multiclass classification

I. Introduction

Machine learning and more recently convolutional neural networks present innovative technologies that are revolutionizing crop disease detection. In this study, we evaluate the use of ResNet architecture, to automatically detect potato leaf diseases.ResNet architecture is well-known for its depth and for avoiding connection problems; it is an excellent solution for drawing out fine features and complex patterns from complex images, making it perfect for plant disease detection. Based on image acquisition and image processing procedures and the qualities of ResNet, we aim to build a detection system that is capable of accurately detecting different potato leaf diseases. Timely and reliable detection of these diseases is required by farmers/sources in any organization.Moreover, this approach further allows for early interventions, such as targeted pesticide usage or modifications to crop management techniques, for reduction in disease incidence and use of resources. The data obtained with the aid of the CNN-based detection model may be used to make crop disease management decisions or provide farmers with data-specific recommendations for enhanced practice and resistance. Ultimately, our research seeks to explore the potential that machine learning has to promote potato cultivation resilience. We believe that modern technologies can be integrated into agriculture to equip farmers with sophisticated equipment to monitor and tackle plant disease, thereby contributing to the achievement of food safety and promoting global sustainable agriculture.

II. Literature Survey

Numerous studies have been conducted on agricultural development, which can enhance economic growth and provide a healthy environment for human beings. Deep learning models and computer vision-based studies have garnered significant attention in accelerating crop production. This section presents a comprehensive summary of previous research work.

Md. Ashiqur Rahaman [1] focused on predicting and classifying potato leaf diseases using a combination of K-means segmentation techniques and deep learning networks. They utilized deep learning models such as VGG16, VGG19, and ResNet50 to classify potato leaf diseases. By applying K-means clustering segmentation and data augmentation techniques, the proposed VGG16 model achieved 97% accuracy in disease classification, outperforming other models. In 2021, Chaojun Hou [2] proposed graph cut segmentation to efficiently segment the potential outline of leaf images. The study employed k-NN, SVM, RF, and ANN classifiers to model the extracted features for disease classification. SVM showed the best performance with an overall accuracy of 95.6% in classifying leaf diseases. Fizzah Arshad [3] proposed a hybrid deep-learning framework for disease classification in crops. The U-Net model was chosen for potato leaf image segmentation in the framework. Feature concatenation and fusion strategies were employed for robust feature extraction. The PLDPNet framework showed superior performance with an accuracy of 98.66%. The paper [4] presents a system to classify four types of diseases in potato plants based on leaf conditions using deep learning with VGG16 and VGG19 convolutional neural network models. The experiment achieved an average accuracy of 91-93%, demonstrating the feasibility of the deep neural network approach. Data augmentation was used to enhance the training process, resulting in improved accuracy in disease classification. The study [5] utilizes Convolutional Neural Networks (CNN) models, particularly the Inception V3 architecture, to analyze leaf images and accurately identify disease symptoms. By training the CNN model on a dataset containing Early Blight (1000 images), Late Blight (1000 images), and Healthy Leaves (152 images), the researchers achieved a high accuracy rate of 90% in classifying the diseases. The paper [6] discusses the application of transfer learning to detect potato diseases from leaf images. They used transfer learning with pre-trained weights from models like VGG16, InceptionResNetV2, InceptionV3, and ResNet50. The VGG16 model achieved the highest accuracy of 99.43%. The authors of the paper [7] discuss the issue of early detection of plant diseases in agriculture. They propose a novel hybrid model that combines a Convolutional Autoencoder (CAE) and a Convolutional Neural Network (CNN) for automatic plant disease detection. The model detects Bacterial Spot disease in peach plants using leaf images. The accuracy of the proposed hybrid model by the authors is 97.75% for detecting Bacterial Spot disease in peach plants using leaf images. The authors also compared the performance of their model with other existing approaches, such as MobileNetV2, VGG16, and ResNet50, and found that their proposed model achieved higher accuracy with fewer training parameters.

The study in paper [8] examines the use of Convolutional Neural Networks (CNNs), specifically EfficientNet, VGGNet, and GoogleNet, in the identification of early potato blight illness. After extensive testing, it is shown that EfficientNet and VGGNet outperform GoogleNet in terms of accuracy, precision, recall, and F-score. To improve accuracy while reducing inference time, the study recommends integrating EfficientNet into a variable-rate smart sprayer for targeted fungicide applications in potato fields. Reducing the usage of agrochemicals, increasing farm profitability, and lowering environmental concerns are all potential benefits of the suggested strategy. The research [9] highlights how this technology could be extended to manage illnesses in a variety of agricultural systems; the next work will require putting EfficientNet in hardware and carrying out thorough evaluations in the lab and the field. The study [10] that is linked looks into the use of deep learning models, a type of artificial intelligence, to identify and categorize plant diseases with a particular emphasis on potato crops. Using a dataset of photos of both healthy and sick potato plants, the study assesses several deep learning architectures, such as CNNs and Transfer Learning. The findings show that the condition was successfully and highly accurately identified. The potential of these models to detect diseases early and support precision agriculture operations is highlighted by the authors. The study provides insightful information about how to effectively manage plant diseases using cutting-edge technologies, laying the groundwork for future advancements in intelligent farming and crop protection techniques.

In paper [11] with a focus on the Tomato Yellow Leaf Curl Virus (TYLCV), the paper investigates the use of deep learning techniques for the automatic identification and categorization of plant diseases from photographs. Convolutional Neural Networks (CNNs) are used in the study to extract features and classify diseases from a collection of photos of both healthy and diseased tomato leaves. The outcomes illustrate how well the suggested deep learning model can distinguish between healthy and diseased tomato plants. By demonstrating the promise of cutting-edge image processing technologies for early and reliable diagnosis of plant diseases, prompt intervention, and enhanced crop management methods, the research advances the field of precision agriculture. Trong-Yen Lee [12] The creation and assessment of a deep learning-based system for the automatic identification and categorization of citrus illnesses in photos are covered in this paper. The study uses Convolutional Neural Networks (CNNs) to extract key features and classify the photos using a dataset that includes images of both healthy and diseased citrus leaves. The model's effectiveness in correctly recognizing a variety of citrus illnesses is demonstrated by the results, highlighting its potential application in precision agriculture.While Baranwal et al. (2019) [14] used CNNs to detect apple leaf disease, Agrawal et al. (2017) used multi-class SVM to detect grape leaf illnesses. Deep CNNs were used by Priyadharshini et al. (2019) and Geetharamani & Arun (2019) for plant leaf diseases and maize illnesses, respectively. Gavhale & Ujwalla (2014) evaluated traditional image processing techniques, while Gutte & Gitte (2016) examined plant disease recognition algorithms. Densely connected CNNs were introduced by Huang et al. (2017).Lee [15] used plant phenotyping, which relies heavily on machine learning, especially deep learning, which calls for sophisticated image processing methods. The use of deep learning in the identification of plant diseases in practical settings was highlighted by Fuentes et al. (2020). In his discussion of agroecology as a science of sustainable agriculture, Altieri [16] highlights the significance of ecological concepts in agricultural methods. Gebbers and Adamchuk examine precision agriculture and how it can improve food security (2010). In his analysis of the connections between pesticides, agriculture, food security, and food safety, Carvalho (2006) emphasizes the importance of sustainable farming methods.While Yu [17] offered Inception convolutional vision transformers specifically designed for plant pathology, Kaya et al. (2023) proposed a multi-head CNN for robust disease diagnosis from RGB photos. CNNs were used by Afakh et al. to detect text in Aksara Jawa, demonstrating the variety of deep learning uses. Kundu [18] used hyperspectral observations to track the severity of late blight, Meno et al. (2021) carried out field evaluations for early blight management. Adolf et al. (2020) addressed disease concerns and offered insights into the management of potato crops.Physiological variations in potato late blight amongst cultivars, biocidal activity of plant-derived compounds against Phytophthora infestans (Najdabbasi et al., 2020), and identification of new Alternaria species on potatoes (Landschoot et al., 2017) are just a few of the aspects of potato disease management covered by the cited literature. Atila [20] used the EfficientNet deep learning model to classify plant leaf diseases, while Bi et al. (2020) used MobileNet to identify diseases on apple leaves. Chen et al. (2021) investigated cognitive vision techniques for plant disease diagnosis.The literature that is cited emphasizes different methods and tools for classifying and detecting plant diseases. J. Chen

[21] and Hernández [21] used Bayesian deep learning to address uncertainty quantification for plant disease diagnosis. The diagnosis was the main emphasis of Javidan et al. (2023).

III. Proposed System

In recent years, ResNet has proven to be a major revolution in the field of computer vision and represents a breakthrough since 2015. Its innovative architecture has led to advances in image recognition and classification and offers great performance and robustness.

ResNet differs from traditional neural networks due to its unique approach to the flow of information between layers. Unlike conventional architectures, where each layer is sequentially connected to the next, ResNet contains residual blocks. These blocks allow direct connections from one layer to another, bypassing intermediate layers. This design not only prevents overfitting, where the model fails to generalize well to unseen data but also solves the vanishing gradient problem that hinders training in deep neural networks. In our effort to tackle the challenge of potato leaf blight detection, we use ResNet9. Leveraging the capabilities of the model's architecture, we aim to develop a robust and accurate system capable of identifying various potato leaf diseases with good accuracy. By using ResNet residual blocks, we expect to perform better in detecting disease patterns, which will ultimately enable farmers to implement early interventions and reduce crop losses.

TABLE I. Training Parameters

S. No	***Parameter***	***Value***
1	Number of Epochs	4
2	Batch Size	32
3	Learning Rate	0.01
4	Optimizer	SGD

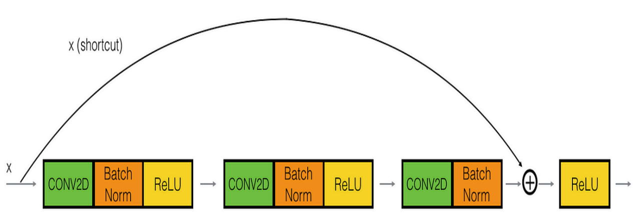

Fig. 1. Resnet9 Architecture

IV. Data Collection

A comprehensive dataset has been assembled, comprising a diverse collection of images depicting potato crop diseases, to facilitate the evaluation of the ResNet9 model for disease detection. This dataset comprises 7134 samples, encompassing a broad spectrum of scenarios encountered in potato cultivation. Specifically, the dataset consists of 2436 images portraying healthy potato crops, 2659 images exhibiting symptoms of potato early blight, and 2660 images showcasing signs of late blight. This comprehensive collection ensures the robustness of the ResNet9 model during both training and evaluation phases.

This meticulously curated dataset serves as a solid foundation for training and evaluating the ResNet9 model in the critical task of potato crop disease detection. By leveraging the ResNet9 architecture's unique features and capabilities, including residual blocks and direct connections between layers, the model is poised to deliver accurate and reliable disease detection results. Ultimately, this effort aims to empower farmers with an effective tool for early disease diagnosis and intervention, thereby minimizing crop losses and optimizing agricultural productivity.

V. Results

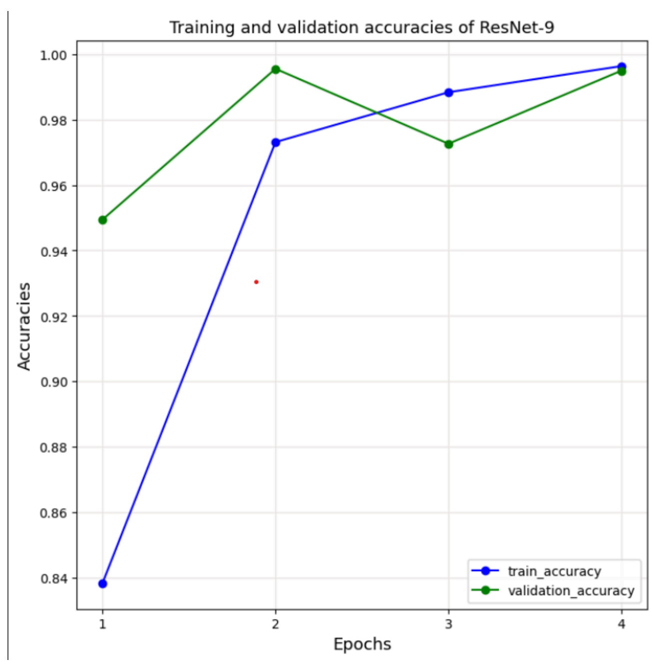

Fig. 2. Training and Validation Accuracy

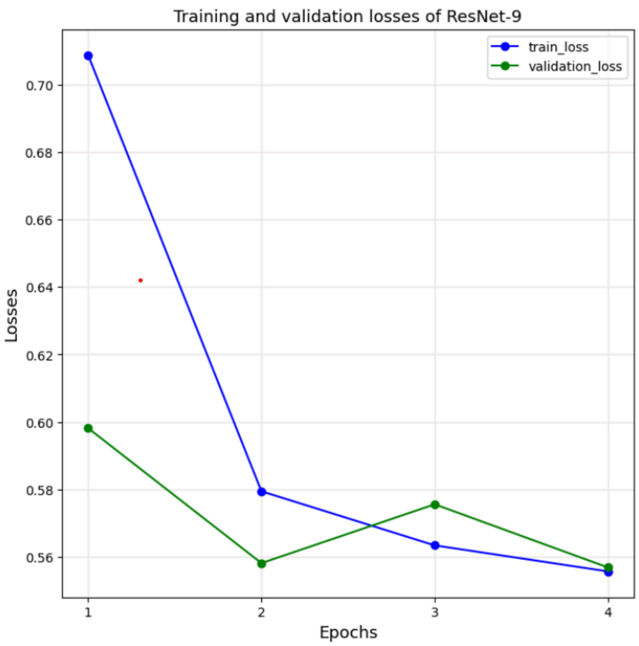

Fig. 3. Training and Validation Losses

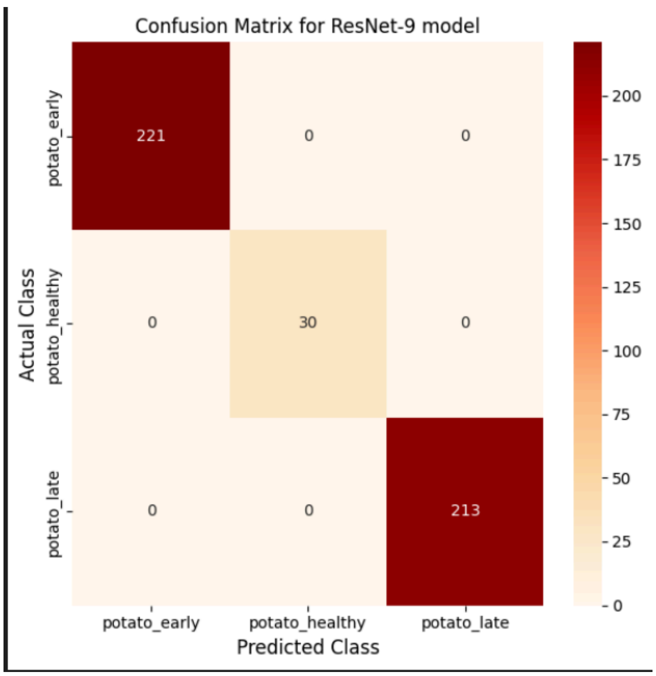

Fig. 4. Confusion Matrix

V. Conclusion

In summary, our study on developing and evaluating the ResNet9 model for potato crop disease detection marks a significant advancement in agricultural technology. We have achieved an accuracy of 99.5 % for predicting potato crop disease.

By assembling a diverse dataset and leveraging the unique architecture of ResNet9, we've created a robust tool capable of accurately identifying various potato crop diseases. Through careful training and testing, we've ensured the model's effectiveness and resilience in real-world scenarios.

VI. References

[1] Predicting and Classifying Potato Leaf Disease using K-means Segmentation Techniques and Deep Learning Networks - ScienceDirect

[2] Recognition of early blight and late blight diseases on potato leaves based on graph cut segmentation - ScienceDirect

[3] PLDPNet: End-to-end hybrid deep learning framework for potato leaf disease prediction - ScienceDirect

[4]https://www.researchgate.net/publication/347449056_Potato_Leaf_Disease_Classification_Using_Deep_Learning_Approach

[5]IRJET-V7I11227

[6](PDF) Application of Transfer Learning to Detect Potato Disease from Leaf Image (researchgate.net)

[7]https://www.researchgate.net/publication/351505791_Plant_disease_detection_using_hybrid_model_based_on_convolutional_autoencoder_and_convolutional_neural_network

[8]Automated recognition of optical image based potato leaf blight diseases using deep learning - ScienceDirect

[9]Automated recognition of optical image based potato leaf blight diseases using deep learning - ScienceDirect

[10]Deep neural network features fusion and selection based on PLS regression with an application for crops diseases classification - ScienceDirect

[11]Potato diseases detection and classification using deep learning methods | Multimedia Tools and Applications (springer.com)

[12]High Efficiency Disease Detection for Potato Leaf with Convolutional Neural Network | SN Computer Science (springer.com)

[13]Plant diseases and pests detection based on deep learning: a review | Plant Methods | Full Text (biomedcentral.com)

[14]https://link.springer.com/article/10.1007/s11042-022-13053-1

[15]https://plantmethods.biomedcentral.com/articles/10.1186/s13007-021-00722-9

[16] https://www.mdpi.com/2077-0472/12/8/1192

[17]https://www.sciencedirect.com/science/article/abs/pii/S1878818123001275

[18]https://www.sciencedirect.com/science/article/pii/S2772375523000084

[19]https://www.sciencedirect.com/science/article/abs/pii/S088557652100182X

[20]https://www.sciencedirect.com/science/article/abs/pii/S1574954121000807

[21]https://www.sciencedirect.com/science/article/abs/pii/S0957417423012198