

Agro-Vision: Intelligent Detection of Potato Leaf Diseases Using Deep Learning.

Pavan Mitragotri ¹, Hrishikesh Mogare ², Vinod Kokitkar ³, Dr. Pavan Kunchur⁴

¹*Pavan Mitragotri Department of MCA KLS GIT, Belagavi, India*

Email : pvmitragotri@git.edu

²*Department of MCA KLS GIT, Belagavi, India*

Email : hrishikeshmogare@gmail.com

³*KLS GIT, Belagavi, India*

Email : vpkokitkar@gmail.com

⁴*Department of CSE KLS GIT, Belagavi, India*

Email : pnkunchur@git.edu

ABSTRACT

Plant diseases are a huge problem for farmers and our food supply. Finding them early is key to protecting crops and getting better harvests. Potatoes are especially vulnerable to diseases example early blight and late blight. If these aren't caught quickly, they can wipe out entire fields and cost farmers higher amount of money. That's why we created Agro-Vision. It's a smart system that uses artificial intelligence to spot potato leaf diseases. The system looks at pictures of potato leaves and tells you if they have early blight, late blight, or if they're healthy. We built Agro-Vision using a special type of AI called MobileNetV2. We trained it on lots of leaf images and used techniques to make sure it works well even when conditions change. The best part? It's really accurate. In our tests, Agro-Vision got things right 90 percentage of the time. When it makes a correct diagnosis, it's usually between 83 percentage and 100 percentage confident about its answer. We made Agro-Vision easy to use by putting it in a simple web app. You can upload a picture of a potato leaf, and it gives you an instant diagnosis along with how confident it is about each possible disease. This makes it a practical tool that farmers can actually use in their fields. What this means is that Agro-Vision offers a reliable, affordable way to catch plant diseases early. It could be a game-changer for modern farming, helping growers protect their crops without needing expensive equipment or expert knowledge.

Keywords: Plant disease detection, Convolutional Neural Networks, Transfer learning, MobileNetV2, Computer vision, Precision agriculture..

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INTRODUCTION

Let's talk about something that affects all of us: our food supply. Agriculture is the backbone that keeps our global food system running and supports economies around the world. But here's the problem - even with all the progress we've made in farming, plant diseases are still wiping out crops left and right. This hurts both how much food we can grow and how good that food is. Now, take potatoes. They're out one of the most popular crops out there, and for good reason. They're packed with nutrients and can grow in all sorts of climates. But potato plants have a serious weakness. They're really vulnerable to diseases like early blight symptoms and late blight symptoms. These diseases can spread like wildfire throughout the fields if you don't catch them early. When that happens, farmers see their yields drop, their costs go up, and their profits take a big hit. So how do farmers usually spot these diseases? Mostly by looking at their crops. They or agricultural experts walk through fields and check plants visually. It's a method that's

been around forever, but it has some real drawbacks. It takes a ton of time and effort, and it all depends on how experienced the person doing the looking is. The accuracy

can vary wildly too - things like lighting, how bad the disease is, and who's doing the inspection all play a role. On big farms, trying to keep an eye on everything becomes nearly impossible. You just can't check every plant all the time. That means diseases often get spotted too late, when it's harder to control them. It's clear we need something better - a solid system or environment that can automatically detect plant diseases accurately and handle large-scale farming. Here's where things get interesting. Recent breakthroughs in deep tech learning and computer vision are changing the game. We now have high tech tools that can automate plant disease diagnosis using images. One approach that's showing real promise involves something called Convolutional Neural Networks, or CNNs for short. What makes CNNs special? They're really good at image classification and pattern recognition. The cool part is they learn this features directly from the images themselves

- no one has to manually tell them what to look for. This is absolutely different from older methods that relied on people creating specific features for the computer to check. Because CNNs learn on their own, they're better at handling variations that would trip up traditional systems. Things like different lighting conditions or backgrounds don't throw

them off as easily. They're building a more flexible, more reliable way to spot plant diseases before they become big problems.

A. Challenges in today's Traditional Disease Detection

Conventional plant disease detection methods rely heavily on visual inspection carried out by farmers or agricultural experts. While this approach is widely practiced, it is time-consuming, labor-intensive, and highly subjective. The accuracy of manual diagnosis largely depends on the experience of the observer and environmental conditions such as lighting and background clutter. In large-scale farming environments, continuous monitoring of crops becomes impractical, often leading to delayed disease identification and ineffective control measures. These limitations highlight the need for automated and scalable disease detection solutions

PROBLEM STATEMENT

Plant diseases such as early blight and late blight pose a high significant threat to potato cultivation by reducing crop yield and quality. Traditional disease detection methods rely more on manual inspection, which result in more time-consuming, subjective, and impractical for large-scale farming. Delayed or incorrect diagnosis often results in uncontrolled disease spread and increased production costs. There is a need for an automated, accurate, and efficient system capable of detecting potato leaf diseases at a primitive stage using image-based analysis.

OBJECTIVES OF THE PROPOSED SYSTEM

The primary objective of this work is to design and develop a deep learning intelligent potato leaf disease detection system using deep learning techniques. The specific objectives of the proposed Agro-Vision system are as follows:

- To classify, sort potato leaf images into early blight, late blight, and healthy categories.
- To utilize transfer learning with the use of a lightweight CNN architecture for efficient performance.
- To achieve reliable disease prediction of leaf with high accuracy and confidence.
- To deploy the trained model using a web-based interface for real-time disease detection.

RELATED WORK

Several research efforts have researched on automated plant disease detection using image processing and deep machine learning techniques. Early approaches primarily focused on handcrafted feature extraction methods, including color histograms, texture descriptors such as Gray Level Co-occurrence Matrices (GLCM), and shape-based features. These features were typically combined with classical classifiers such as Support Vector Machines, k-Nearest Neighbors, and Random Forests. Although these techniques achieved reasonable accuracy under a well developed controlled laboratory conditions, their performance degraded significantly in real-world environments due to variations in illumination, complex backgrounds, leaf

occlusion, and differences in disease severity. With the advancement of deep learning, researchers increasingly adopted Convolutional Neural Networks (CNNs) for plant disease detection. CNNs automatically learn hierarchical and discriminative features directly from raw images, eliminating the need for manual feature engineering. Sladojevic et al. demonstrated the effectiveness of deep CNN architectures for leaf disease recognition and reported high classification accuracy on publicly available datasets. Mohanty et al. further investigated and researched the use of transfer learning by fine-tuning pretrained CNN models on plant disease datasets, achieving improved generalization across multiple crop species. Ferentinos evaluated several deep learning architectures and showed that CNN-based approaches consistently outperform traditional machine learning methods in large-scale agricultural applications. Despite their success, many existing deep learning models are computationally expensive and require

high-end hardware resources, making them unsuitable for real-time or mobile deployment in practical agricultural settings. Models such as VGG and ResNet offer high accuracy but suffer from large model sizes and increased inference time. To address these limitations, recent studies have focused on lightweight architectures optimized for efficiency without sacrificing performance. The proposed Agro-Vision system builds upon this direction by employing MobileNetV2, a lightweight CNN architecture designed for resource-constrained environments. By leveraging transfer learning and an optimized model design, Agro-Vision achieves an effective balance between accuracy, speed, and computational efficiency for real-world potato leaf disease detection.

PROPOSED METHODOLOGY

The proposed Agro-Vision system is designed to automatically detect potato leaf diseases using deep learning and image-based analysis. The overall workflow includes dataset preparation, image preprocessing, CNN-based feature extraction, disease classification, and deployment through a web-based interface.

SYSTEM IMPLEMENTATION

The system is implemented using Python and deep learning frameworks such as TensorFlow and Keras. The trained model is integrated into a Streamlit-based web application that allows users to upload potato leaf images and receive real-time disease predictions along with confidence scores. The application provides an intuitive interface suitable for practical agricultural use.

Dataset Description

The dataset used in this study consists of potato leaf images categorized into three classes: early blight, late blight, and healthy leaves. The images are organized into class-specific folders and resized to a uniform resolution to maintain consistency during training. Sample images from the dataset are shown in Fig. 1.

Image Preprocessing and Augmentation

Image preprocessing is performed to improve data quality and enhance model performance. All images are resized to 224×224 pixels and normalized to scale pixel values between 0 and 1. I use RGB color conversion. RGB color conversion keeps the colors the same across all inputs. To reduce overfitting and improve generalization, data augmentation techniques such as random rotation, horizontal flipping, zooming, and shifting are applied during training. These techniques enable the model to perform effectively under real-world conditions.

CNN Model Architecture

The disease detection model uses the MobileNetV2 architecture. The MobileNetV2 architecture is an efficient neural network. The MobileNetV2 architecture supports real-time applications. The disease detection model uses pretrained ImageNet weights to set up the base model. The final classification layers are replaced with a global average pooling layer, a

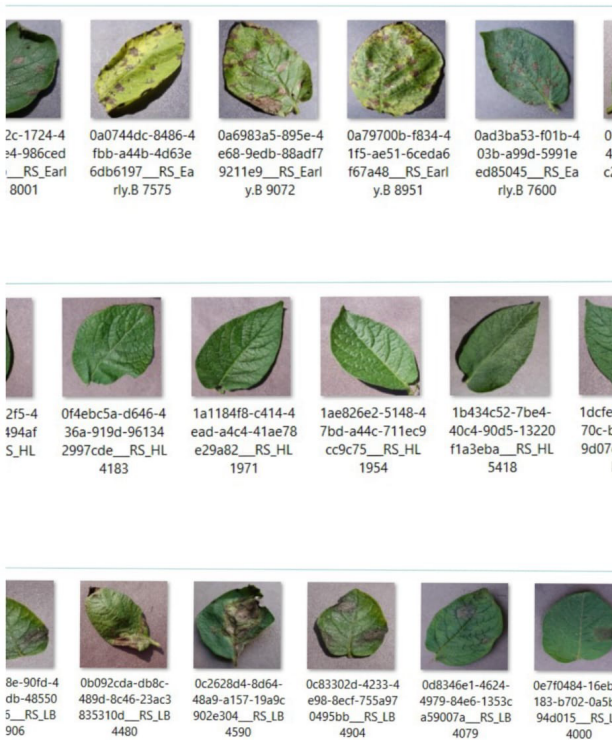


Fig. 1. Sample potato leaf images from the dataset: (a) Early blight, (b) Late blight, and (c) Healthy leaf

fully connected dense layer, dropout regularization, and a softmax output layer. The architecture of the proposed model is illustrated in Fig. 2.

Model Training and Deployment

The model is trained using the Adam optimizer and categorical cross-entropy loss function. The dataset is divided into training and validation sets to evaluate performance and prevent overfitting. During training, the base layers of MobileNetV2 are frozen while the newly added layers are fine-tuned. The trained model is deployed using a Streamlit-based web application that allows users to upload potato leaf images and receive real-time disease predictions along with confidence scores.

RESULTS AND ANALYSIS

The performance of the proposed Agro-Vision system is evaluated using training and validation accuracy and loss metrics. The experimental results demonstrate effective learning and stable convergence of the model.

A. Confidence Scores

The deployed Agro-Vision system generates confidence scores for each potato leaf disease class, indicating the reliability of the predicted output. Higher confidence values are observed for correctly classified samples.

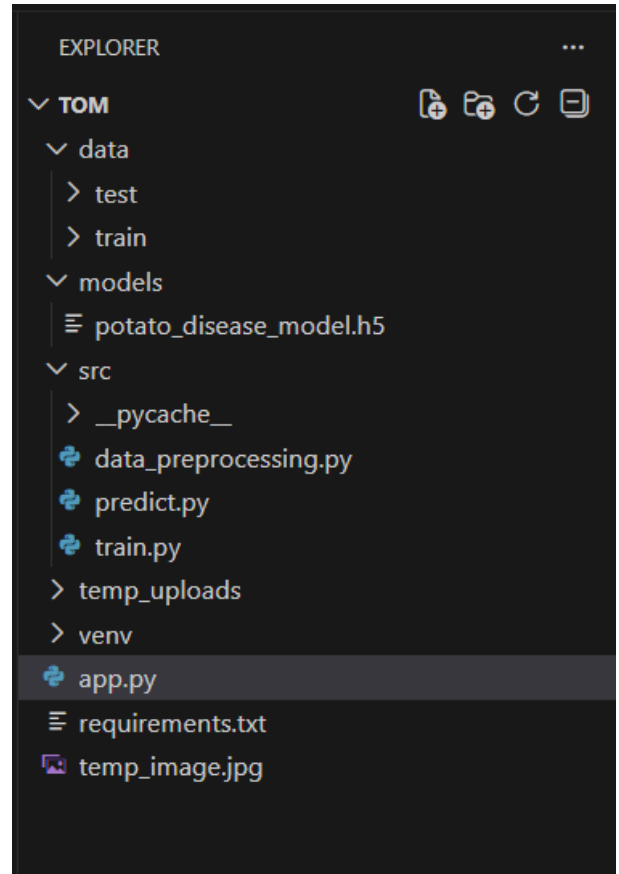


Fig. 2. Architecture of the proposed CNN-based potato leaf disease detection model

CONCLUSION

This paper presented Agro-Vision, an intelligent potato leaf disease detection system based specifically on deep learning and transfer learning using MobileNetV2. The proposed approach achieves high classification accuracy while also maintaining low computational complexity. The web-based deployment enables real-time and user-friendly disease diagnosis. Future work includes extending the system to multiple crops, deploying the model on mobile platforms,

and incorporating disease severity estimation for enhanced decision support.

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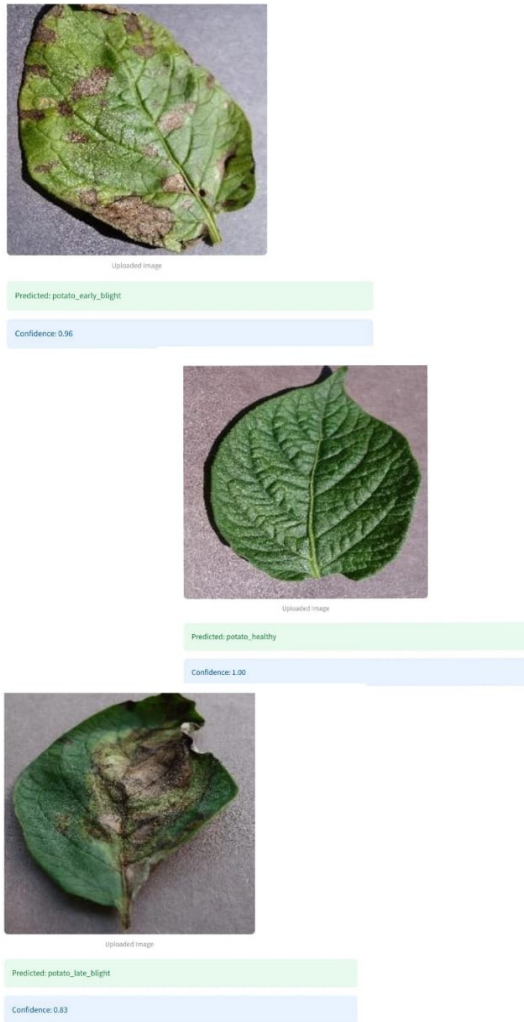


Fig. 3. Prediction confidence levels for early blight, late blight, and healthy potato leaf categories

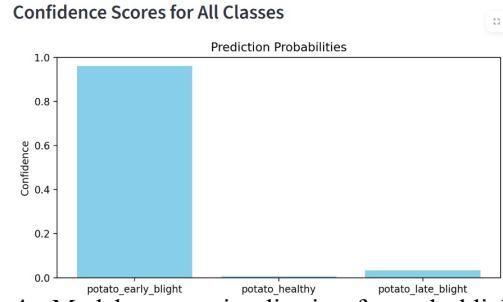


Fig. 4. Model output visualization for early blight potato leaf disease

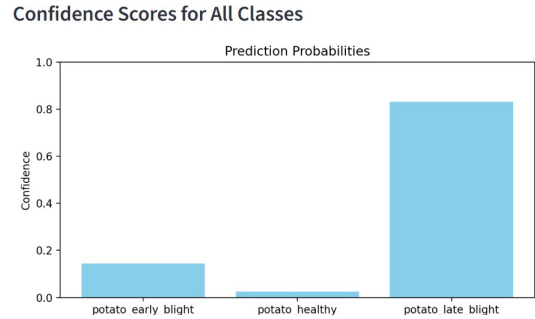


Fig. 5. Model output visualization for late blight potato leaf disease

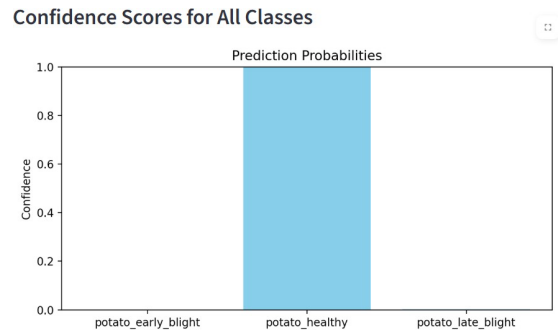


Fig. 6. Model output visualization for healthy potato leaf classification

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