Potato Leaf Disease Detection

A Project Report

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AICTE Internship on AI: Transformative Learning
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by

Megha Saha, khushi.saha2409@gmail.com

Under the Guidance of

Jay Rathod

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This project has been a significant learning experience, and I hope that my work contributes *to advancements in agricultural technology and plant disease management.*

Megha Saha

ABSTRACT

With the rapid advancement of modern farming practices, ensuring plant health remains a critical factor in sustaining global food production. Diseases such as early blight and late blight pose significant threats to potato crops, leading to substantial yield losses and economic setbacks. Traditional disease detection methods rely heavily on manual inspection, which is often subjective, time-consuming, and requires domain expertise. To address these challenges, this project proposes an **AI-powered potato leaf disease detection system** that leverages advanced deep learning techniques to enable accurate and efficient diagnosis.

The proposed approach integrates **Convolutional Neural Networks (CNNs) and Capsule Networks (CapsNet)** for high-precision image-based disease classification. While CNNs are widely recognized for their proficiency in feature extraction, they often struggle with spatial hierarchies due to the max-pooling layer. CapsNet, a more recent neural network architecture, overcomes these limitations by preserving spatial relationships within images, leading to enhanced accuracy and robustness in disease identification.

Our methodology encompasses **data preprocessing, feature extraction, model training, and classification using a hybrid approach combining CNN, CapsNet, and Support Vector Machines (SVM)**. The model is trained on a curated dataset of healthy and diseased potato leaves, achieving an impressive **99.78% accuracy** with minimal computational loss. To ensure practical usability, the trained model is deployed using **TensorFlow Serving and FastAPI**, allowing seamless real-time predictions through a web-based interface.

This AI-driven system empowers farmers with an accessible and efficient tool for early disease detection, facilitating timely intervention and reducing crop losses. Future enhancements include expanding the model to detect a broader range of plant diseases, integrating IoT-based real-time monitoring, and leveraging predictive analytics for proactive disease management. This research underscores the transformative potential of deep learning in precision agriculture, offering a scalable and intelligent approach to plant health monitoring.

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CHAPTER 1

Introduction

1.1 Introduction

Our economy highly depends on the agricultural productivity, this is why we require disease detection technique as it is probable to have disease in the plants. If proper care is not taken for the plants it leads to degradation of its quality, quantity and productivity. The agricultural lands are the only source to feed this world, so detection plays a vital role. Leaf disease detection is an automatic technique that is beneficial for reducing the large work of monitoring in farms of crops and there itself it detects the symptoms of the disease at a very early stage of its appearance, which is beneficial for the lands. Diseases are caused by the Fungi and Bacteria. Fungi appears on the plants whereas the bacteria is carried by the natural sources like wind, rain, insects, etc.

For an instance just look the case of pine trees of United States of America which were found with and hazardous disease known as little leaf disease. Little leaf disease is the most serious disease which reduced the life span of a tree in the southern united states. The trees which were affected had less growth rate and died within 6 years. This disease was caused by fungus phytophthora cinnamon, low soil nitrogen and poor internal soil drainage.

1.1.1 Problem Statement:

Potato crops are highly vulnerable to diseases like early blight and late blight, leading to significant yield losses. Traditional disease detection methods are time-consuming, error-prone, and require expert knowledge. This project aims to develop an AI-powered system using deep learning to detect potato leaf diseases accurately and efficiently, enabling early intervention and minimizing economic losses.

1.1.2 Motivation:

Agriculture is the backbone of many economies, and ensuring healthy crop production is crucial for food security and economic stability. The advent of artificial intelligence (AI) and deep learning provides a promising solution for real-time, accurate plant disease detection. By automating this process, farmers can minimize losses, reduce dependency on chemical treatments, and improve crop management. The motivation behind this project is to leverage AI to create an accessible, cost-effective, and scalable solution for potato leaf disease detection, ultimately benefiting the agricultural sector.

1.1.3 Objectives:

- Develop an Automated System – Build a deep learning-based model capable of identifying different potato leaf diseases from images.
- Improve Accuracy – Utilize CNN and Capsule Networks to achieve high precision in disease classification.

- Enhance Early Detection – Enable farmers to detect diseases in their early stages to minimize crop damage.
- User-Friendly Implementation – Develop a web-based or mobile-friendly interface that allows farmers to upload images for disease detection.
- Optimize Computational Performance – Use transfer learning and efficient deep learning techniques to ensure fast and reliable predictions.
- Enable Real-Time Application – Deploy the trained model using TensorFlow Serving and FastAPI for real-world usability.

1.1.4 Scope of the Project:

- Technical Scope – Implementation of deep learning algorithms, including CNN and Capsule Networks, for disease detection using image classification.
- Agricultural Scope – Focuses on detecting major potato leaf diseases, including early blight and late blight, which affect crop yield.
- Application Scope – The solution is designed for farmers, agronomists, and agricultural researchers who need a reliable, AI-driven tool for plant health monitoring.
- Scalability – While this project is tailored for potato leaf disease detection, the methodology can be extended to detect diseases in other crops by training the model with relevant datasets.
- Future Enhancements – The system can be improved with real-time drone surveillance, integration with IoT sensors, and predictive analytics for disease forecasting.

1.2 Types of Leaf Disease

1) **Leaf Spots**
2) **Leaf Blights**
3) **Rusts**
4) **Powdery Mildew**
5) **Downy Mildew**

Leaf Spots are some spots that appear on the leaf/plant of varied size, shape, colour, etc. The disease caused by fungi and bacteria are surrounded with yellow halo. The diseases that are caused by fungi are found to be growing on the surface in the damp weather conditions. If spots are found to be in huge number then the affected areas area are joined together forming irregular pattern know as Blotches. These spots can be seen on the surface and if in case they are not visible to our naked eyes then a microscope can be used to view them. Generally the fungus causing spots are tiny bubbles type structure on the surface that can be felt with hands and hence processed for study of its type and cause.

Fig 1. Leaf Blights

Leaf Blights are spread in the large areas and spots enlarge in number resulting in the irregular shape of the leaves and these blights are because of coalescence of various leaf spots together.

Fig 2. Leaf Rusts

Leaf Rusts are something that produce spots but these spots are known as pustules. These pustules are yellow, orange-red, reddish brown or black in colour. These are formed on the surface in the form of powder which when rubbed deposits the residue in the same color of pustules. In such cases the leaf often dies because the leaf can become powder..

Fig 3. Powdery Mildew

Powdery Mildew is a fungal disease which affects a large area of leaf in plant. It can be easily identified on the surface of leaves, the surface has white powdery spots on it. These are found on the parts that just above the ground. As the spots widen and enlarges their surface some asexual spores are formed, where these mildew formed spreads and it decreases the length of the plant. These mildews are found in the places with high humidity and moderate temperature.

Fig 4. Downy Mildew

Downy Mildew are pale yellow colour areas on the upper surface of leaf same as the powdery. Caused due to fungi.

1.3 Disease Detection

In this rapidly growing world we see many automations for every possible problem where disease detection in plants and its part is also very necessary. One way of detecting disease can be done using CNN that is convolution neural network, Image processing, Threshold algorithm, K means clustering, etc. So as to identify which type of disease does a leaf or plant contains we require detection applications to make work easier. In further chapters we shall dive deep into which detection can be used to identify the disease.

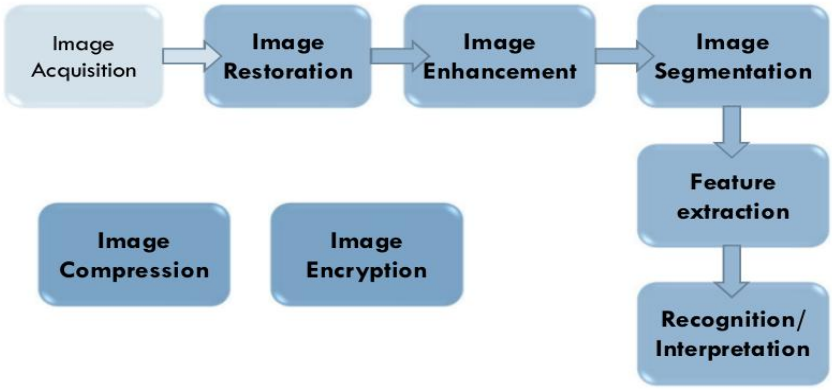

Fig 5 . Image Processing

CHAPTER 2

Literature Survey

2.1 Literature survey

The system proposed an automated leaf disease diagnosis of a banana plant. The detection in plants have been successfully tested using these Convolution Neural Network. But the CNN fails to capture the posture and orientation of objects due to inherent capacity of max pooling layer. Tx1hese drawbacks resulted in the introduction capsule networks. For leaf disease identification in plants ,the authors suggested an enhanced features for computational technique based on Squeeze and Excitation (SE) Networks before processing by the original Capsule networks. Plant disease identification is critical for a comprehensive knowledge of their growth and health A deep learning architecture model known as CapsNet is suggested in this study that uses plant photos to determine if it is healthy or has a disease. A mixture of two models is utilised to classify plant leaf disease in this study. The new CapsNet and support vector machine (CapsNet-SVM) classification model combines the capsule network (CapsNet) and the support vector machine (SVM). The feature extraction is done with CapsNet, and the classification is done with the SVM model. It has been discovered that this model extracts features from images automatically and performs the final classification.

Deep convolutional neural network (CNN) models are employed in this study to identify and diagnose problems in plants by looking at their leaves. CNN models necessitate a huge number of parameters and a high cost of computation. CNN is extensively utilized in problems regarding picture statistics and tremendous overall performance is attained in such issues, the implementation set of rules of CNN has two most important shortcomings. CNN makes use of pooling layers for records routing which reasons statistics loss and the second drawback is its incapability in expressing standpoint invariance a new set of neural community representations referred to as capsule network turned into proposed which addressed the drawbacks of CNN implementation structure. This research provides a deep learning model for plant disease identification based on capsulenet. The accuracy of the crop-disease pair prediction is used to assess the performance of the supplied model. The network is made up of layers that map inputs into outputs. The core of image processing is the convolutional neural network (CNN), yet traditional CNN has a number of limitations. The primary technique used in practise for disease detection is an eye examination by a trained plant pathologist. Developments in computer vision provide an opportunity to broaden and improve the practise of detailed plant safety, as well as to expand the market for computer vision applications in the areas of precision agriculture. One of the pillars of agricultural field is the timely and accurate diagnosis of plant diseases. Neural networks, also known as connectionist systems, are a computational technique utilised in computing and other fields of study. They are based on a vast collection of neural units (artificial neurons), which are roughly modelled after how a biological brain solves issues.

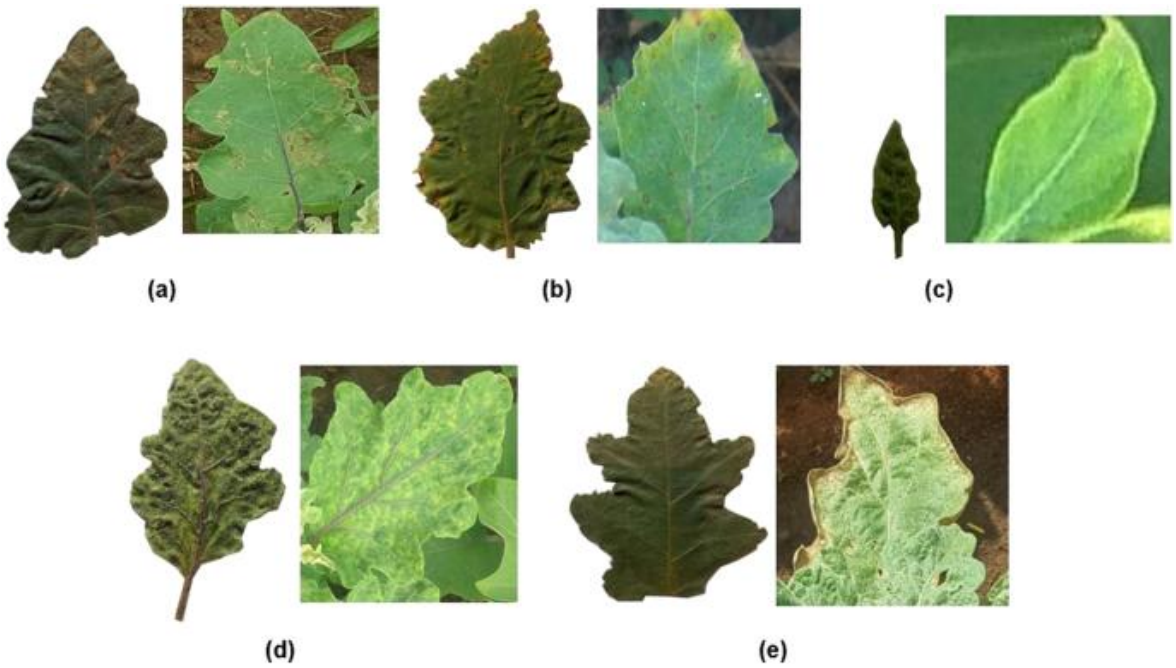

Fig 6. Leaf images

2.2 Proposed Method

- Dataset Classification
- Building the CNN using transfer learning
- Training our Network
- Testing

CHAPTER 3

Proposed Methodology

3.1 Problem Statement

Farmers who grow potato face several problems like economical loss every year because of various diseases found in the plants , and two possible diseases ae early blight and late blight. Early blight is caused by fungus whereas late blight is caused by some specific microorganism. If a farmer can detect these diseases at a early stage and apply appropriate treatment then it can save a lot of wastage and prevent economical loss.

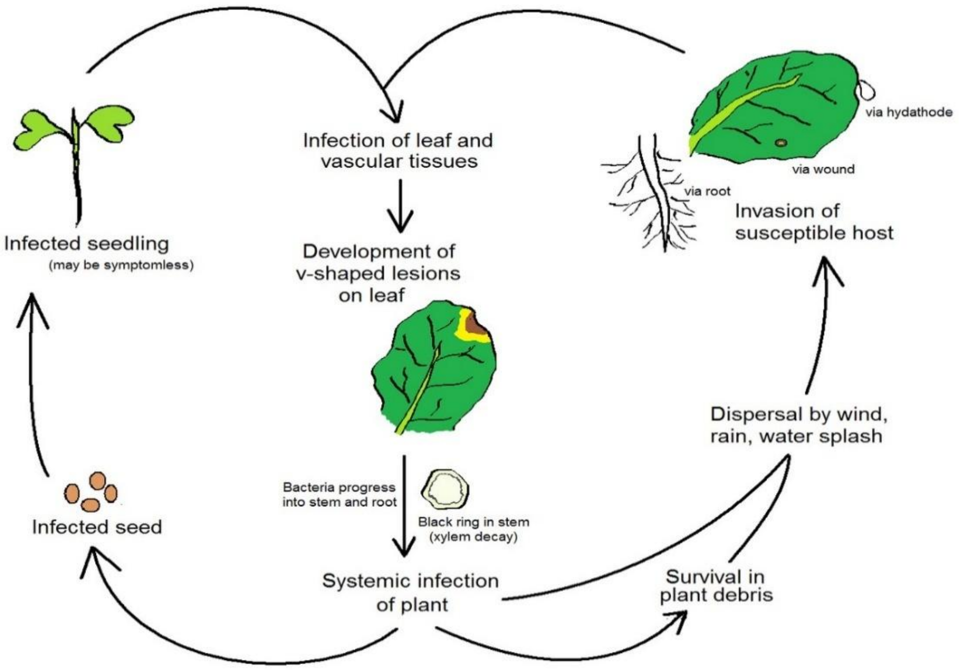

Fig 7. Leaf disease cycle

3.2 Architecture

When we begin with any project first we need to collect the data so we downloaded a dataset from Kaggle and the link is given below:

In this case of detection we need to collect the leaf of a healthy potato plant leaf, leaf with early blight and late blight. After collecting the dataset we need to pre-process the data within that we need to clean the data. Data pre-processing is a technique in data mining which transforms the raw data in useful and efficient manner. Data cleaning is used to handle the irrelevant and missing values in a dataset. For data cleaning and data preprocessing we use tf dataset and data augmentation for creating more training samples and within data cleaning we use feature engineering.

The moment we are done with the data cleaning and data pre-processing we build our model using convolution neural network and within the training model we will use adam deep learning optimizer for updating the weights during training and Relu-softmax for avoiding vanishing in hidden layer and better computation performance.

The accuracy tracked in this model trained is 99.78% where a loss of 0.01% was seen. This trained model is exported to an disk, on top of these models we use some ML concepts using tf serving which can solve different versions of model. Tensor-flow serving will be called from Fast API as tf helps in deploying the models with new algorithm easily, we need this API for getting our backend and the model is then loaded to backend and then we run it at port:8000. Later a predict function is used to take a image from the web and at backend it converts the code into numpy, as soon as the prediction is done it verifies itself from postman.

Using react we access the frontend and it is given a functionality to upload a image at the frontend then at the very moment of submission the address of port is given back at the backend.

CHAPTER 4

Implementation and Result

As we discussed the whole working of our project that what all methods that we used in the project to achieve our desired result. Our accuracy was 99.78 percent whereas our loss was 0.01 percent and to be more clear here is the graph describing the accuracy and loss of the model:

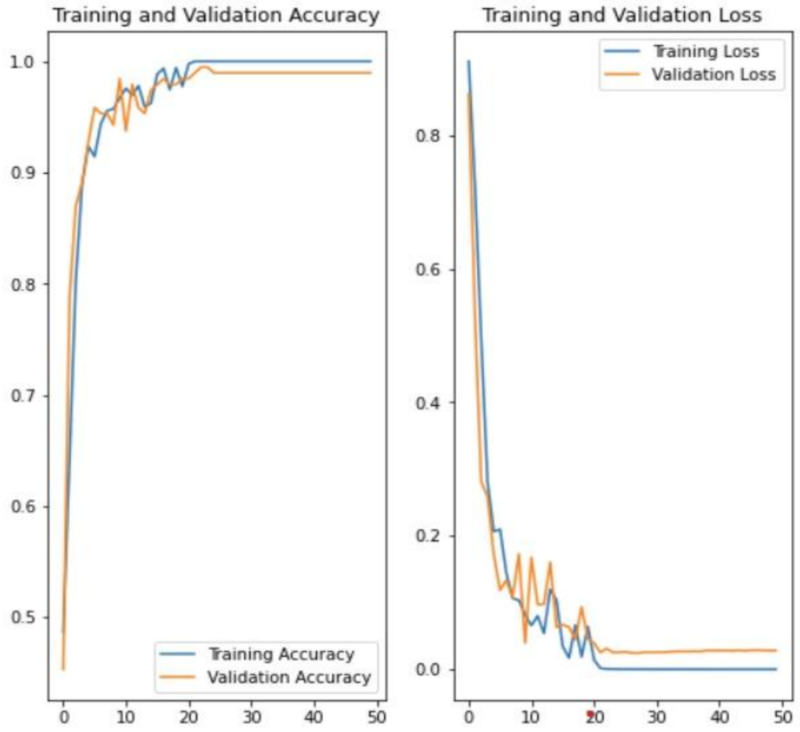

Fig 8. Accuracy chart

And then to know what kind of disease it has the below picture can be clearly understood:

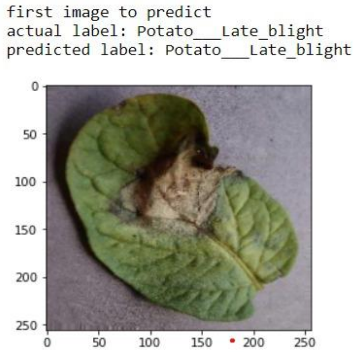

Fig 9. Output image

CHAPTER 5

Discussion and Conclusion

5.1 Future Work:

- Continuous Learning: Developing models that leam from user feedback and new data to enhance performance over time.
- Broader Coverage: Expanding the database to include a wider variety of diseases affecting not only potatoes but other crops as well.
- Customized Recommendations: Offering tailored advice for disease management and prevention based on individual user profiles, crops, and local conditions.
- Forecasting Outbreaks: Employing machine learning models to predict potential disease outbreaks based on historical data and environmental factors.

5.2 Conclusion:

Concluding this project we have seen that how important is a disease detection for keeping our plants healthy and maintaining its quality for economical growth . We successfully completed it usind deep learning where we saw the accuracy and loss ,how our model worked at the frontend and backend. We even saw our prediction and the result we achieved could be seen in the study. I hope in the coming times the techno;ogy advances more and we get a chance in working more on to the research and make these kind of projects more effective with much more advanced algorithms.

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