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Predictive Analysis of Potato Plant Diseases using Deep Learning Models: A Comparative Study

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***Abstract*—In today's agricultural landscape, potato plant diseases create significant challenges to food security globally and agricultural productivity. Early detection and identification of these diseases is very important for managing disease management. This research paper focuses on the application of deep learning models for predicting potato plant diseases. By exploring various deep learning architectures, including convolutional neural networks, the main motive of this study is to develop a model which can accurately detect potato disease. The study utilizes a diverse dataset comprising images of healthy potato plants and plants infected with different diseases to train and evaluate the deep learning models. Through a comparative analysis, the study evaluates the performance of different deep learning approaches in terms of accuracy, efficiency, and robustness. Additionally, the study investigates the factors such as dataset size, model complexity, and hyperparameter tuning on the predictive performance of the models. Overall, the main aim of research was to provide valuable insights into the efficiency of deep learning techniques for potato plant disease prediction.**

KEYWORDS: Potato Plant Diseases, Deep Learning, Predictive Analysis, Convolutional Neural Networks, K-nearest Neighbors, Comparative Study

I. Introduction

Potato farming is a vital component of agricultural production worldwide. However, the growth and yield of potato crops are threatened by many diseases, including late blight, early blight, and black scurf. These diseases have the potential to cause significant economic losses for potato farmers. Therefore, there is a pressing need for effective disease prediction and management strategies to safeguard potato crops and ensure food security. In response to this need, our research aims to harness the power of machine learning to predict potato disease onset, allowing for timely intervention and mitigation of potential crop damage[2].

To detect diseases in potato leaves, farmers mostly rely on human examination, which is labour-intensive and prone to error. The application of cutting-edge technologies like computer vision (CV), deep learning, artificial intelligence (AI), and others is highly beneficial in the current technology era for expediting the prediction of potato diseases. The agriculture sector has experienced a significant increase in the use of artificial intelligence (AI) and deep learning owing to its powers in picture identification, processing, classification, and prediction[3].

It has been shown that a type of machine learning known as deep learning is very adept at categorizing photos. Among the many tasks for which Convolutional Neural Networks (CNNs) are employed are object recognition and picture categorization. This effort involves fine-tuning an efficient deep learning model to forecast potato leaf diseases. Following training on a dataset of images of potato leaves, the model's performance is improved through the use of techniques including data augmentation, transfer learning, and hyper-parameter tweaking. To evaluate the model's performance, metrics such as loss and performance accuracy are employed. We also compared our model with different algorithms such as SVM, Random Forest, KNN to determine the better algorithm to use for the model. The need for a precise and practical method to forecast potato leaf disease is what motivates our research, as crop management depends on early disease diagnosis.

II. Literature Survey

The need for plant disease detection arises from the importance of monitoring and maintaining the health of plants. Plant diseases can significantly impact the quality and quantity of agricultural yields. Therefore, accurate and timely detection of plant diseases is crucial in the agricultural sector. The research paper highlights the significance of accurate and timely detection of plant diseases to ensure the health and productivity of plants. The research paper emphasizes the importance of monitoring and maintaining plant health, as diseases can have a significant impact on agricultural yields. The research paper emphasizes the importance of accurate and timely detection of plant diseases in order to monitor and maintain the health of plants. The significance of accurate and timely detection of plant diseases is emphasized in the research paper. The research paper presents a new practical plant disease detection system using cucumber leaf images. This system addresses the need for accurate and timely detection of plant diseases, which is crucial for monitoring and maintaining the health and productivity of plants. The importance of plant disease detection lies in the need to monitor and maintain the health of plants[9].

The provided source discusses a literature survey on potato plant disease detection using CNN techniques. The literature survey discussed in the provided source focuses on the use of Convolutional Neural Network techniques to detect diseases in potato plants. The authors present an overview of various studies and methods employed in the field of potato plant disease detection using CNN. They highlight the importance of accurate and timely disease detection in potato plants for effective management and yield optimization. The researchers conducted a comprehensive literature survey on the use of Convolutional Neural Network techniques for detecting diseases in potato plants. They reviewed numerous studies and methodologies in this area. The studies reviewed in the survey demonstrated the effectiveness of CNN techniques in accurately identifying and classifying potato plant diseases[5].

The provided source discusses a study on potato plant disease detection using CNN techniques. The study presented in the provided source focuses on the use of Convolutional Neural Network techniques for detecting diseases in potato plants. The study conducted in the provided source aims to utilize CNN techniques for accurate disease detection in potato plants. The researchers collected a dataset of potato plant images and trained a CNN model to classify the images into healthy and diseased categories[10].

The introduction presents an overview of the research on plant leaf disease detection using image processing techniques. It discusses the importance of automated disease detection in agriculture and the challenges associated with manual diagnosis. The research focuses on using image processing techniques for plant leaf disease detection. It highlights the steps involved in the disease detection process, including image acquisition, image pre-processing, image segmentation, feature extraction, and classification. The paper also emphasizes the need for accuracy and expertise in plant diseases, as well as the time-consuming nature of traditional diagnosis methods. Additionally, the paper mentions that image-based assessment approaches have been found to produce more accurate and reproducible results compared to human visual assessments[11].

The research paper presents a new practical plant disease detection system using cucumber leaf images. The system utilizes a large dataset of 7,520 cucumber leaf images, consisting of healthy leaves and those infected by various viral diseases. The system employs image processing techniques for accurate and low-cost automated diagnostic of plant diseases. The paper proposes a new plant disease detection system using cucumber leaf images[15]. The proposed system utilizes a large dataset of cucumber leaf images to create an accurate and low-cost automated diagnostic system for plant diseases. The research paper provides an overview of a new practical plant disease detection system using cucumber leaf images. The paper introduces a new practical plant disease detection system that utilizes cucumber leaf images[12].

III. Methodology

The methodology used in the paper are many different algorithms like CNN, KNN, SVM and Random Forest compared to give the more accurate technology to use for prediction. We divided the process in 2 different steps.

A. Image Processing

Image processing is a vital process in model training. Image processing is a method of manipulating the data to extract useful data from images for the model to use.

Image processing block diagram is shown in Fig.1.

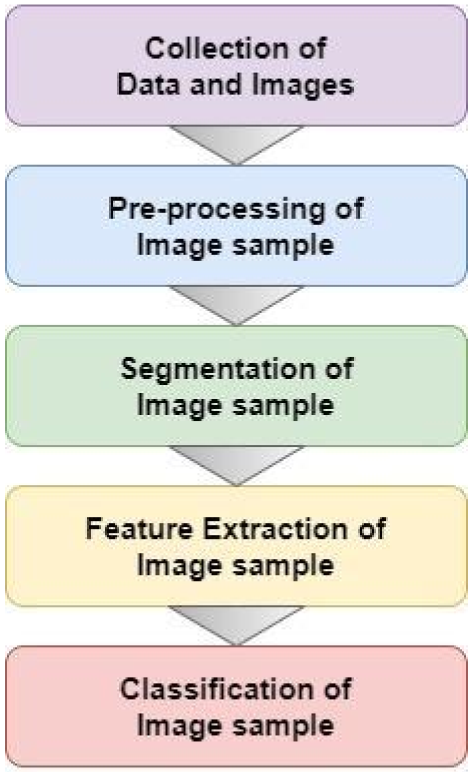

Fig.1 : Image Pre-processing

1. Data Collection

Gather information on factors like leaf health using photographs clicked using a camera showing different conditions of leaves showing if the leaf is healthy or blighting. We have collected data using datasets from data repositories like Kaggle and also collecting data from local farmers. Around 3000 different photos of leaves have been collected for this research.

2. Image Pre-processing

To increase the variability of the dataset, we implemented the use of data pre-processing. Pre-processing is a process in which the images are modified to reduce the non-essential distortions and also sometimes to enhance some image features for other processing[6]. Image cropping for the required area and image enrichment like brightness and contrast are adjusted in order tom achieve image pre-processing.

3. Segmentation

Image segmentation assigns a name to each pixel, ensuring that pixels with the same label have similar visual features. It makes images easier to evaluate during image processing operations. Image segmentation divides a digital picture into segments based on homogeneity criteria (e.g. colour, intensity, texture) to identify objects and boundaries[7].

4. Feature Extraction

In plants, there could be many different features we could monitor but to specifically narrowing it to give a better accuracy on the detection. For our research we are going to monitor the leaf blight of the potato plant i.e. if the leaves are healthy or early blight has occurred or late blight has occurred shown in fig.(2)

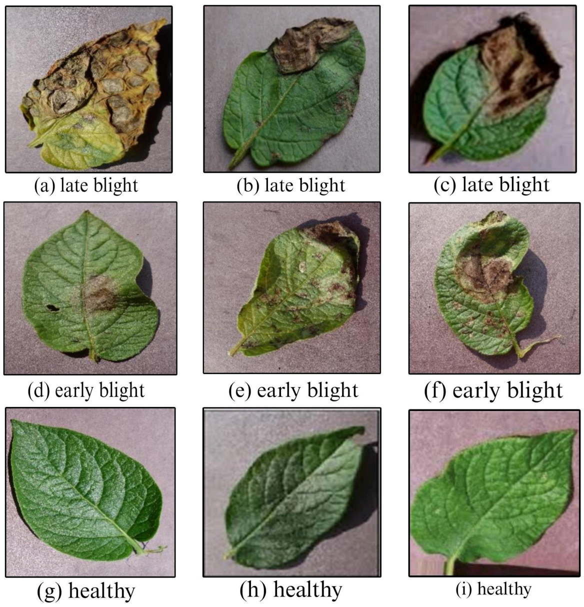

Fig.2 : Classification of Features

5. Classification

Colour and texture characteristics are extracted, then classified using Support Vector Machine (SVM). A support vector machine creates hyperplanes in a high-dimensional space to do classification, regression, and other tasks[8].

B. Model Training

There are many types of models that can be used for plant disease detection from traditional machine learning algorithms to deep learning models. We are using the following algorithms for proposed methodology:

1. Support Vector Machines(SVM)

SVMs are powerful traditional supervised learning models used for classification tasks. SVMs can be trained on features extracted from images to classify plants as healthy or diseased.

2. Random Forest Classifier

Random Forest is a cooperative learning method that creates multiple decision trees during training. It's robust to overfitting and can handle large datasets with high dimensionality. Random Forest can be trained for classification tasks in plant disease detection, utilizing image features.

3. K-nearest Neighbours

KNN is a simple and in-built classification algorithm. It classifies objects based on majority class among their k nearest neighbours in the feature space. KNN can be applied to plant disease detection by computing distances between feature vectors extracted from images.

4. Convolutional Neural Networks(CNN)

CNNs are deep learning models which are designed to analyse visual data like images. They include multiple layers of convolutional and pooling operations. CNNs can learn hierarchical representations of images, making them highly effective for image classification tasks like plant disease detection.

To train ML algorithms, such as Artificial Neural Networks and deep learning models, using selected features and disease occurrence data. We use 70% of our dataset for model training. We train the models through various algorithms while mainly focusing on CNN.

CNN consist of multiple interconnected layers, with every layer doing a specific task in the feature extraction and classification process. The CNN algorithm is formed through various layers : convolutional layer, pooling layer and fully connected layers shown in fig. 3.

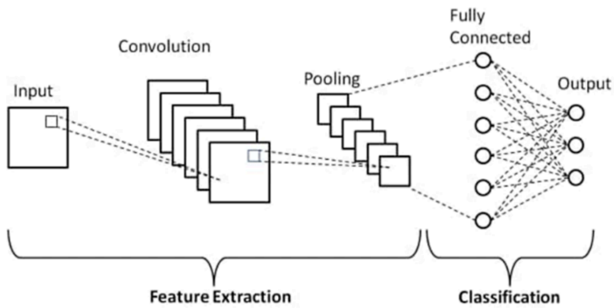

Fig. 3 : Flow of CNN Algorithm Working[14]

- Feature extraction and hierarchical learning:

It helps to extract images and apply filters to input images. This process is used to achieve higher accuracy in many computer vision tasks

- Pooling layer in CNN :

It plays an important role in reducing spatial dimensions of feature maps and acquire the more important information.

- Fully Connected layers and classification:

It is a last step of CNN for mapping the learned features to the classes. It receives the output from layers, flattens and then gives a single vector that acts as an input for next stage for output[13].

IV. RESULT AND CONCLUSION

After building our model, we test it by using the remaining 20% of our dataset on different algorithms like Support Vector Machine (SVM), K-nearest Neighbour (KNN) classifier, Random Forest classifier, Convolutional Neural Network (CNN) and determine accuracy for each algorithm to give us the algorithm that provides the highest accuracy. After testing, we incurred following results which are also shown in fig.4

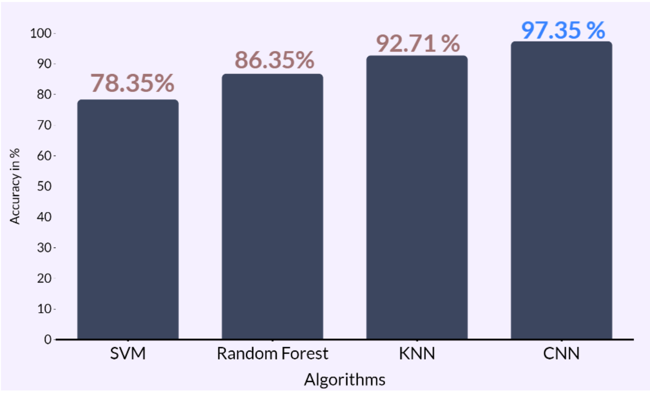

Fig. 4 : Comparison of Different Algorithms

1. SVM

Using SVM we observed a 78.35% accuracy in detecting the correct output.

2. Random Forest Classifier

Using Random Forest, we observed a 86.75% accuracy in detecting the desired output.

3. KNN

While using KNN, we observed a healthy 92.71% accuracy which is optimal in much cases.

4. CNN

While using CNN, our proposed model gave accuracy of 97.35% which ensures lesser mistakes in identifying the disease.

After more no. of epochs are performed the model ensures better accuracy as the CNN model learns from previous epochs to provide more accuracy shown in fig.5.

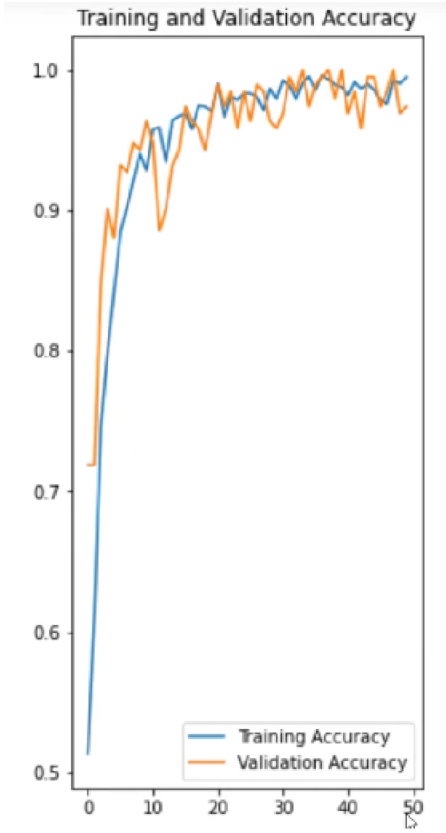

Fig.5 : Performance Estimation of Training and Validation Accuracy

CNNs (Convolutional Neural Networks) are generally preferred over SVMs (Support Vector Machines) and KNN (K-nearest Neighbours) for image classification because of their ability to learn hierarchical features from images automatically.

CNNs are designed to copycat the visual processing in the human brain, where early layers capture low-level features like edges and textures, and deeper layers learn more complex and abstract features. This hierarchical feature learning allows CNNs to adaptively extract relevant information from images, making them highly effective for capturing intricate patterns that are crucial for image classification. Also, CNNs utilize convolutional and pooling layers to maintain the spatial hierarchy of features, which is crucial for recognizing objects regardless of their position or orientation within an image.

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