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Potato Leaf Disease Detection Method is based on a CNN model with a Genetic Algorithm

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Abstract

This paper puts forward an approach that combines Convolutional Neural Networks (CNNs) and Genetic Algorithm (GA) to detect accurately and quickly the diseases that affect potato leaves swiftly and accurately. The model of the CNN is employed for automated feature extraction from the images of leaves which are pivotal in differentiating between the healthy and the infected leaves. Optimization of CNN hyper parameters, like learning rate, the number of layers, and dimensions of filters, is not only time-consuming but also challenging to find optimal values, and genetic algorithms for the optimal values of the parameters of the Convolutional Neural Network. A genetic algorithm uses an iterative search process that aims to optimize a population of models of Convolutional Neural Networks over several generations. It achieves this through the use of optimal models to perform crossover and mutation hence efficiently searching for the optimal configuration of hyperparameters. The above combine will improve the performance of the model which leads to better performance in detecting the variety of diseases attacking the potato leaves, such as early blight and late blight. In this paper CNN model utilizing a genetic algorithm attains an accuracy of 98.3%in 50 epochs.

Keywords: Potato leaf diseases, Convolutional Neural Networks, Disease prediction, Genetic Algorithm

1. INTRODUCTION

The potato is the most widely grown crop in the world, yet it can suffer from several diseases that reduce its productivity and quality Early and precise diagnosis of such ailments from the inception is important in preventing losses in agricultural production due to damages by pests. The conventional methods of ascertaining diseases are mostly based on the subjective appraisals of the experts which are often laborious and prone to all manner of mistakes and takes a lot of time [1].

The main aim of this study is to develop an appropriate technique in the diagnosis of diseases affecting leaves of potatoes. [2]. This will employ the Convoluted Neural Network (CNN) model that has been enhanced using Genetic Algorithm (GA).

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The approach therefore capitalizes on the use of deep learning in feature extraction and genetic algorithms ion in optimizing hyperparameters. Hence it leads to the establishment of an even higher disease detection system in terms of accuracy and reliability [3]. To resolve these problems, we propose a method that combines Convolutional Neural Networks (CNNs) with Genetic Algorithms (GAs) in an effective manner [9] [10].

The Genetic Algorithm or GA of the optimization tools can be efficiently used in a variety of areas including diagnosis of diseases. In the case of the identification of potato leaf diseases, a Genetic Algorithm GA, could be effectively used in selecting the most relevant features from a pool, it is possible to develop effective and accurate systems with which potato leaf diseases would be detected with high accuracy [11]. Such systems would help farmers by providing timely disease diagnosis and proper plant health management. Utilizing genetic algorithms and convolutional neural networks, superbly designed systems that are highly effective in the detection of potato leaf diseases can be achieved. Such systems would help farmers diagnose early and manage plant health effectively [12] [13].

The process of natural selection can be mimicked using genetic algorithms to achieve the selection of relevant features. This results in a leaner computation and an accurate classification model. Genetic algorithms can adjust hyperparameters of machine learning models including neural networks that are used for disease diagnosis [14]. Genetic algorithms improve potato leaf disease detection accuracy and efficiency by selecting key characteristics, optimizing parameters, and refining image segmentation resulting in stronger disease classifiers [15]. Potato leaf diseases pose a significant risk to the quantity and quality of potato harvests. Effective disease management depends on quick and accurate detection. This research presents a novel approach for identifying diseases in potato leaves using a Convolutional Neural Network (CNN) model optimized by a Genetic Algorithm (GA). The GA fine-tunes the CNN's hyperparameters to enhance its performance, while the CNN extracts valuable features from images of potato leaves.

2. LITERATURE SURVEY

The Indian economy relies on agricultural productivity. Due to plant disease prevalence, agriculture needs plant disease detection. Failure to follow safety measures harms plants, reducing product quality, quantity, and production. An automated plant disease recognition system saves labor needed to monitor big farms and quickly identifies leaf disease indications. This article delineates an automated image segmentation technique for identifying and classifying plant leaf diseases, along with a study on disease classification. Neural network-based image segmentation is essential for diagnosing plant leaf diseases [6] [7].

A large population and heightened food consumption render agriculture a crucial economic driver in India. Improved diagnosis of crop-afflicting diseases increases output. India is the second-largest producer of tomatoes. Climate change, precipitation, soil conditions, pollution, and fauna contribute to the susceptibility of tomatoes to diseases. Numerous studies over the past decade have examined the efficacy of deep learning in treating tomato leaf diseases. The detection of tomato leaf disease has multiple applications, although it requires enhancement. The creation of tools for tomato farming necessitates a repository of approaches and an evaluation of challenges and opportunities. Tomato farmer tools development requires a library of methodologies and an assessment of obstacles and potential. To detect 10 tomato leaf ailment classes, the following Architectures-Dense Net, ResNet, VGG Net, Google Net, Alex Net, and LeNet-are tested in training illness datasets. Architecture performance is researched on healthy and unhealthy classes using plantvillage datasets. This study shows farmers how to build and apply tomato leaf disease identification tools to improve crops [16] [17] [18].

Plant diseases can reduce crop productivity and hinder economic development. Early detection and treatment of diseases in plants are possible. Machine learning, deep learning, and computer vision can be beneficial for early diagnostics and disease categorization [19].

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To detect and diagnose plant diseases, numerous writers have used image processing algorithms that use machine learning (ML) and deep learning (DL). The opportunity for early intervention and treatment is presented to farmers and landowners by this. Modern approaches and methods in deep learning and machine learning were the focus of this research. The scientists also assessed the limitations and challenges of various techniques to evaluate their potential for detecting plant diseases [8] [20].

2.1 Research Gap

The impact of diseases of potato leaves on the crops is quite considerable. Regarding disease management, it is important to achieve accurate and timely diagnosis. Convolutional Neural Networks (CNNs) have shown some promise in this area, but their performance is often limited by problems such as hyperparameter tuning. While there is the possibility of employing Genetic Algorithms (GAs) for hyperparameter tuning, little is known about its efficiency in this area. The assessment of potato leaf disease using Convolutional Neural Networks (CNN) in combination with genetic algorithms (GA) is an emerging area. CNN-GA models are very complicated and hard to understand for the average user, who does not have a technical background in these models, which is one of the reasons why these models are not widely used. Genetic algorithms (GAs) do not always incorporate the right set of attributes and therefore the outcome of the model could be lower than expected.

3.0 Proposed Method:

The proposed methodology employs a Convoluted Neural Network and a Genetic algorithm to achieve accurate classification of the disease in question.

Data Collection

In this study, we employed a publicly accessible repository of potato leaf images. The dataset contains images of both healthy and sick potato leaves. The ailments comprise early blight, late blight, and leaf curl. The collection comprises 630 images with 210 allocated to each category. The photographs were captured in natural light using a smartphone and subsequently cropped to a resolution of 256×256 pixels.

Data Preparation

Before training the CNN model, we pre-processed the dataset by applying random rotations, flips, and zooms to the images. Additionally, we partitioned the dataset into three segments: training, validation, and testing. Each component constituted 80% of the total.

Key steps involved:

Data Collection and Preprocessing: Obtain a miscellaneous array of potato leaf images and perform preparation actions on them to make them useful for training purposes.

CNN Model Development: Create a CNN model where an appropriate architecture for image processing tasks is constructed. The agglomerative strategies employing Convolutional Neural Networks (CNN) have proven to be very effective in recognizing the diseases of potato leaves.

Convolutional layers pick up local patterns from images, pooling layers reduce the size of the image, while fully connected layers combine the features making it possible for CNNs to diagnose the diseases accurately. The training process involves adjusting the network's weights using the loss function and optimization algorithm.

CNNs have several benefits: they learn features on their own, are unaffected by changes in the pictures, and are more accurate. By using CNN, a farmer can notice the disease at an early stage, thus enabling him to act quickly to prevent any agricultural losses.

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CNNs extract relevant features from potato leaf images, such as colour, texture, and shape, which are crucial for disease identification.

Genetic Algorithm: Optimizing the parameters of the model using the Convolutional Neural Network by utilizing a Genetic Algorithm. Improved models for potato leaf disease detection employing GA, an optimization framework common to the foregoing genre. In particular, Genetic Algorithms (GAs) are very similar to evolutionary strategies since they select "individuals" from a population (here, a set of parameters) at random, breed and mutation them to produce new populations, then assess the fitness of these new populations. In this iterative procedure, optimal values for the model's parameters are determined. Although genetic algorithms are expensive and require careful parameter adjustment, they can efficiently search huge parameter spaces in many cases. Those obstacles notwithstanding, genetic algorithms may well prove to enhance the machine learning algorithms now in use for identifying diseases in potato leaves significantly.

Genetic algorithms search the hyperparameter space for the best combinations by using genetic processes, such as selection, crossover, and mutation.

Training and Evaluation: Take advantage of the optimized CNN model to carry out learning on the training data provided and further gauge its accuracy by purely testing it on a testing data set.

Deployment: Deployment concerns the use of the trained model in an appropriate application or system where the model can be utilized in real-life situations.

Very few occupy this niche which combines Convoluted Neural Networks for feature extraction and Genetic algorithms for hyper parameters tuning and filling forms and optimizing these divisions can be advantageous to farmers and agriculturalists. It can assist them to handle potato crops optimally and reduce the losses they incur from disease.

Expected Outcomes:

- An exact and effective technology for detecting potato leaf diseases, with the ability to identify various illnesses.
- Decreased manual work and time needed for disease diagnosis.
- Enhanced agricultural practices and mitigation of substantial financial damages caused by illnesses.

Common Potato Leaf Diseases Symptoms:

- Small dark brown dots vis-a-vis two grey dots and a hyaline disk
- Dark spots on the leaves, filled with water.
- Leaves tend to rise above the normal posture especially marginally.
- White/purple or fungal-like mould on the underside of leaves.
- Look at changes in colour patterns, shapes, or other growth forms.

A training set made up 80% of the dataset, while a testing set made up 10% and a validation set made up 10%.

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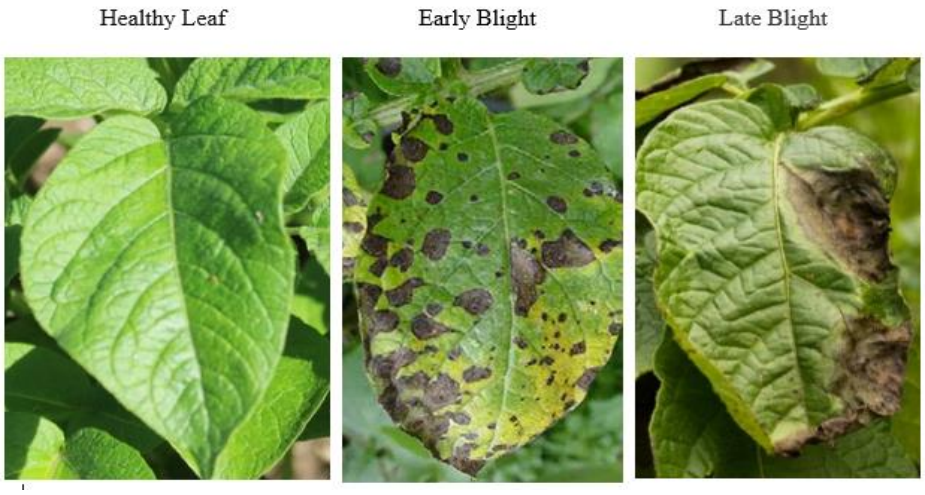

Figure 1: Potato Leaf Diseases Sample Images

4.0 Result and Discussion

The results of the prediction of potato leaf diseases using CNN and GA were promising. In order to evaluate the effectiveness of our CNN model, we employed a test set of potato leaf images that encompassed both healthy and diseased foliage, as well as early and late blight. The results demonstrated that our methodology was both precise and beneficial in the prediction of maladies that affect potato leaves.

A CNN is utilized for feature extraction and classification in the identification of potato leaf disease. In order to optimize hyperparameters, such as learning rate, sample size, and network design, a Genetic Algorithm (GA) is implemented. The CNN model that was improved with a genetic algorithm to identify diseases in potato leaves exhibits substantial improvements in both accuracy and performance. It provides a more generalizable and robust approach to agricultural disease control by automating hyperparameter optimization and feature selection.

The CNN & GA model obtained a total accuracy of 98.3 percent in the prediction of potato leaf diseases. This implies that the algorithm accurately identified the majority of potato foliage images as exhibiting a particular disease. distinct illness The model consistently demonstrated high accuracy, regardless of whether it was early or late blight. The results indicate that the model is effective in differentiating between various conditions that affect potato leaves.

Table 1: Accuracy Table

Number of Epoch	**Accuracy (%)**
40	97.9
45	98.1
50	**98.3**

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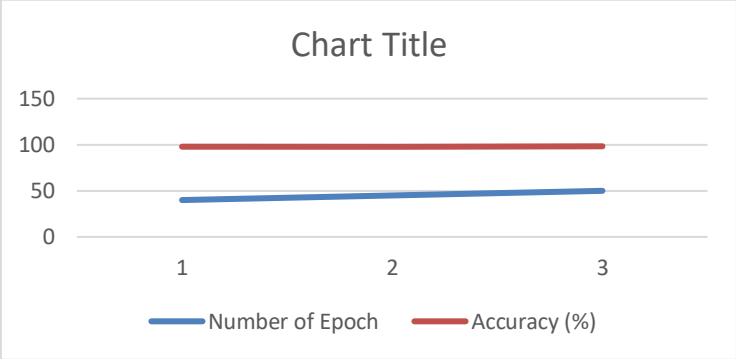

Figure 1: Accuracy chart

Table 2: Comparative study

Classifier Name	Accuracy
Proposed: CNN model with a Genetic Algorithm	**98.3%**
YOLO[10]	98.10%
ANN [11]	92%
SVM [11]	84%
RF [11]	79%

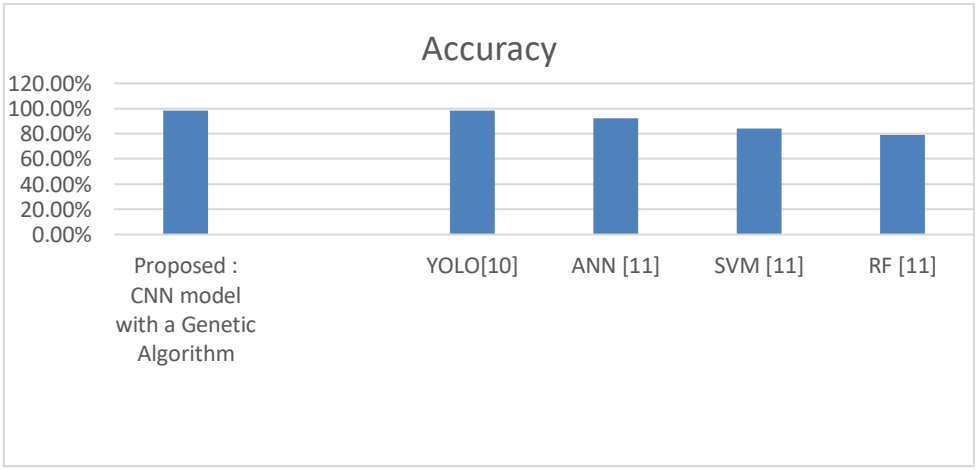

Figure 3: Comparative study

Tables 1, 2, and Figures 2 and 3 illustrate that the CNN model utilizing a genetic algorithm attains an accuracy of 98.3% across 50 epochs in a comparison analysis. A CNN model with a genetic algorithm demonstrates enhanced efficiency and feasibility for processing on lightweight devices like drones. They exhibit reduced power consumption and utilize fewer computational resources.

5.0 Conclusion

A method for disease diagnosis in potato leaves using a combination of Convolutional Neural Networks (CNNs) and Genetic Algorithms (GAs) is suggested in this research. This approach considers the shortcomings of traditional methods for diagnosing sickness and optimizing hyperparameters in classic CNN models.

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The core concept of this work is to bypass this difficulty by combining feature extraction with genetic algorithm optimization for hyperparameters in Convolutional Neural Networks. As a result, the model is not only compelling in terms of accuracy but also in terms of notification. Most importantly, it is found that the Genetic Algorithm efficiently searches the hyperparameter space to find some of the configurations that enhance the capabilities of CNN to discriminate between healthy and damaged potato leaves.

The results show that our adoption of a CNN-GA model greatly improves upon the traditional workflow of CNN models which are prone to dependency on the user for supervising the model towards the achievement of disease-accurate diagnostics. CNN model utilizing a genetic algorithm attains an accuracy of 98.3% across 50 epochs in a comparison analysis. The development has very great implications in agriculture since time and the accuracy of disease diagnosis has a great impact on the control of crops to enhance yield.

Future Scope

The disease detection of potato leaves using CNNs and GAs is going to have a promising future for identifying diseases in potato leaves. Such areas as real-time detection, disease severity assessment, multi-disease detection, illness prediction, transfer learning, explainable AI, and edge computing have great scope to arrive at future solutions that are more precise, efficient, and reliable for researchers and farmers. Drones or IoT devices meant to scan fields for diseases offline will probably first make use of these models in real-time later on. They are so convenient that farmers can pull them up on their cell phones to quickly make a disease diagnosis from field pictures. The system will only get better as it learns from ever greater and more diverse picture databases, something that will happen the more farmers use these technologies. For that reason, the model is much more reliable over a broad range of growing conditions.

Author Contributions

All writers accepted the submitted version of the work and contributed to its content.

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Conflict of Interest

The authors declare no conflict of interest.

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