AgriJaanch: *An Efficient Solution for Ensuring Sustainable Agricultural Growth using Artificial Intelligence*

*Chirantan Das[1], Kamal Singh[2] and Sumit Gupta[3]
[1-3]*University Institute of Technology, The University of Burdwan,*
Golapbag (North), Burdwan- 713104, West Bengal, India
[1]*cse.20201021@gmail.com* [2]*singh540kamal@gmail.com* [3]*sumitsayshi@gmail.com*

Abstract - With the advancement in agricultural technology and the use of Artificial Intelligence in diagnosing plant diseases, it becomes important to make pertinent research for sustainable agricultural development. We have proposed and built a Web-based system to spread awareness amongst Farmers and Agro-companies about various diseases that plants are infected with and also their possible remedies. Different diseases have different causes and thus different solutions and mitigation strategies need to be adopted. If the diseases are misjudged or mismanaged, then they can get spread profusely and wreck havoc on the soil. So we came up with a potential approach for effective, efficient and automated detection of the prevalent diseases during the budding phase of the agricultural products to assist the farmers in employing preventive measure on time. We have developed a set of both Machine Learning Models and Deep Learning Models to detect diseases in the potato plant. The models are deployed on our website and when the image of a Potato plant is uploaded, the result that whether there is any disease in the plant or not will be generated. Amongst all models trained and tested in this work, Convolutional Neural Network yields the best classification accuracy of 99.30%.

Keywords - Deep Learning; Convolutional Neural Networks; Feature Extraction; Plant Disease Detection; Image Classification

1. Introduction

There are various types of occupations in the world but it is well-known that agricultural farming is the most crucial amidst all. Indian economy is not an exception to it because it heavily depends on the agricultural produce. Potato is very significant crop grown in India and production-wise our country is the second largest producer of potatoes after China with 51.3 million tons produced in the year 2020 alone that amounts to 14.30% of the total potato production in the world (FAOSTAT, 2020).

The increasing demand of crops has triggered the necessity to think of an alternative solution to deal with the crop wastage due to both natural and artificial causes which results in lower harvest rates. Diseases have adverse effects on plants and agricultural lands. The main causes of these diseases are microorganisms, genetic disorders, and infectious agents like bacteria, fungi, and viruses.

The world is moving with a very fast pace and to walk hand-in-hand with the latest technology and modernized ambience, we need to explore horizons yet undiscovered or unexplored. There are number of modernized systems offering various agricultural services. Though such applications are available but they cannot be accessed easily by the peasants in the rural area. Furthermore, the implementation of Machine Learning (ML) Models is required to predict diseases in the crops efficiently and thereby recommend proper remedies to aid the farmers constructively. So, the focus should be on developing a Web Portal that can solve the issue of crop health management, keeping in mind the need to provide a reliable and easily accessible application to the farmers.

This requirement let us into proposing an image classification system based on Convolutional Neural Network (CNN), where the images of different plant leaves will be processed and analyzed to achieve accurate prediction of diseases. Thus, rather than depending on any particular image, all the training set images will contribute in building the image recognition and classification system so that other devices using the application could only feed the query image and get the required data over it with ease and precision.

Earlier many researchers in the field of computer vision and image processing proposed to use traditional image processing techniques like LBP (Huang & Dasgupta, 2018), K-means clustering (Li & Wu, 2012) for detecting plant diseases from its leaves. Deep Learning (DL) Models are better at mapping functions and hence are better feature generators. So, we have created a DL Model using CNN to detect and predict diseases from the leaves of a potato plant and have further compared the classification results with several other classifiers in this paper.

The rest of the paper is divided into various sections, where section 2 discusses the literature review showcasing work done in the allied area by other researchers, section 3 presents the description and working principle of our proposed plant disease detection system, section 4 highlights the implementation strategy and the results obtained therein and finally the paper ends with the conclusion and future scope of improvement.

2. Previous Related Works

After studying numerous published works in the domain of plant disease detection, a lot of interesting facts came to the fore. Before the evolution of Deep Learning, the popular classification approaches that were used for disease detection in plants include Random Forest (Simonyan & Zisserman, 2014), Artificial Neural Network (ANN) (Sheikhan et al., 2012), k-Nearest Neighbor (KNN) (Guettari et al., 2016), and Support Vector Machine (SVM) (Deepa & Umarani, 2017). However, these approaches were dependent on the extraction and selection of visible disease features.

Recently, several works on automated plant disease diagnosis and identification have been developed using DL techniques (Chen et al., 2020)(Tiwari et al., 2020). One of such work (Kawasaki et al., 2015) proposes the CNN architecture to recognize diseases from a cucumber leaf and obtained 94.9% accuracy. CNN is the most popular classifier with multiple benefits (Kabir et al., 2021) for image recognition in both small and large-scale datasets. It has shown excellent performance in image processing and classification.

3. Proposed Methodology

The proposed disease detection system has been explained in this section in the form of its architectural framework, its flow diagram and the working principle on which the system functions.

3.1 Proposed Architecture

Nowadays, applications of Deep Convolutional neural networks are widely used in medical, agricultural fields etc for various purposes such as in Computer Vision (Krizhevsky et al., 2012) and thus we developed a model like ResNet (Szegedy et al., 2017) in our case to extract the relevant features of the dataset. The architectural design of the proposed system has been described with the help of a simple diagram shown in Fig. 1 next.

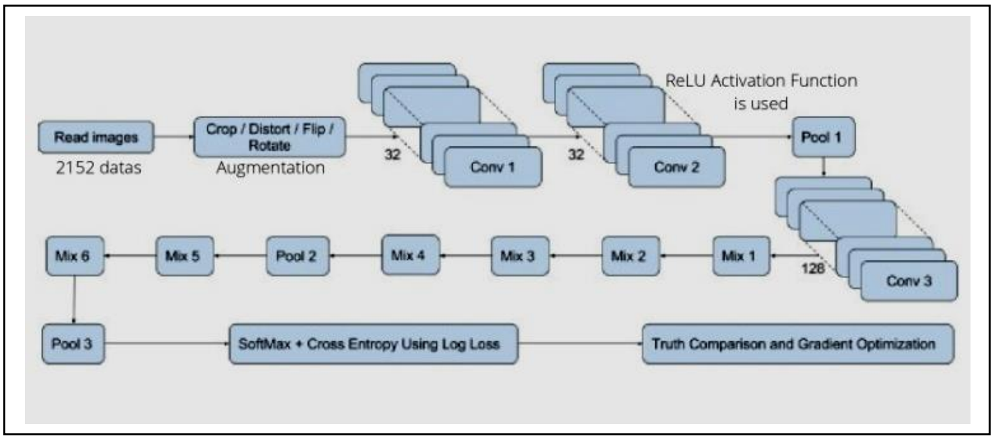

Fig. 1 The Simplified ResNet Architecture used in our Proposed System (Sharma et al., 2020)

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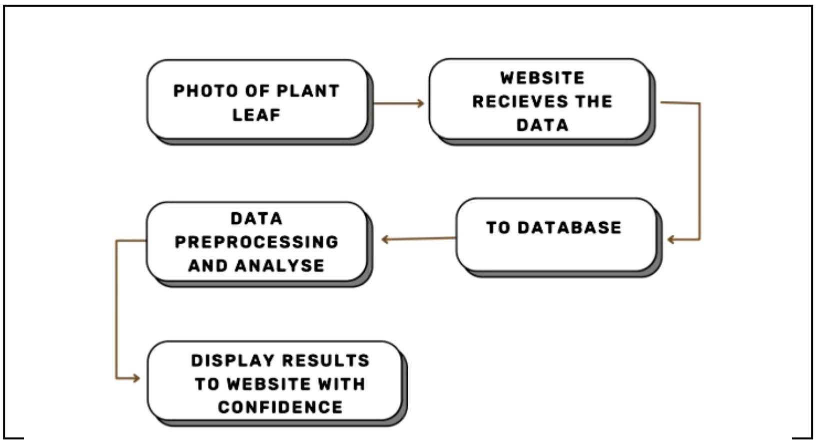
3.2 System Workflow

The working of our proposed system is depicted using a flowchart in Fig. 2.



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3.3 Working Principle

There are basically two main components of our proposed system:

1) *Deep Learning model:* The DL model has been created using Python in Jupiter Notebook and Convolutional Neural Network is used for the task of Image Classification.

2) *Web Portal:* A user-friendly environment has been provided through the website created with the help of WordPress themes in Frontend and PHP in Backend.

The Python libraries such as Numpy, Pandas, Statistics and Tensorflow Framework is loaded into the console which are required for model building. Then the dataset is loaded which contains 2152 potato leaf images with two kinds of diseases viz. Late Blight disease and Early Blight disease.

Some constants are defined such as:

IMAGE_SIZE = 256 BATCH_SIZE = 32
CHANNELS = 3 EPOCHS = 20

The Image size is set to 256 as we are taking 256x256 pixel image, Channels is set to 3 as we have 3 layers RGB, Batch size and Epoch are taken 32 and 20 respectively for efficient execution of the Forward and Back Tracking technique used to calculate the precise Gradient decent.
The Image dataset is then preprocessed where each image undergoes Rescaling into a same dimension and Resizing in a 256x256 matrix for each Channel. Then the images are Augmented as if some rotation is required such that all the leaf axes are parallel to each other.
To build the Machine Learning model, we have used the Convolutional Neural Network (CNN) algorithm, where we have used Conv2D() function (which is used in 2D-Image classification) and MaxPool() of 2x2 array is taken from each batch. Max pooling extracts the most important features like edges whereas, average pooling extracts features quite smoothly. For image data, max pooling is better for extracting the extreme features.
Batch normalization changes inter-layer outputs into a standard format and re-calibrates each of the data values based on the mean and variance for a specific data batch.
Then each layer is fitted to a ReLU Activation function which makes the network more powerful and adds the ability to it to learn something complex and complicated form data and represent non-linear complex arbitrary functional mappings between inputs and outputs.
Flatten() is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector. In final dense state evaluation Softmax Activaion function is used for precise multi-label classification of plant species identification and detecting disorder. To calculate the loss, we have used binary cross-entropy in the architectures.
The Website is a WordPress-based product where various awareness articles are being provided to the user along with a portal to input the leaf image to be analyzed. We have written a PHP script which will take an image as input and then show the result with confidence after being examined as shown in Fig. 3. All the data will be monitored thoroghly so that the data can be used to contribute to increase the accuracy of the disease detection system.

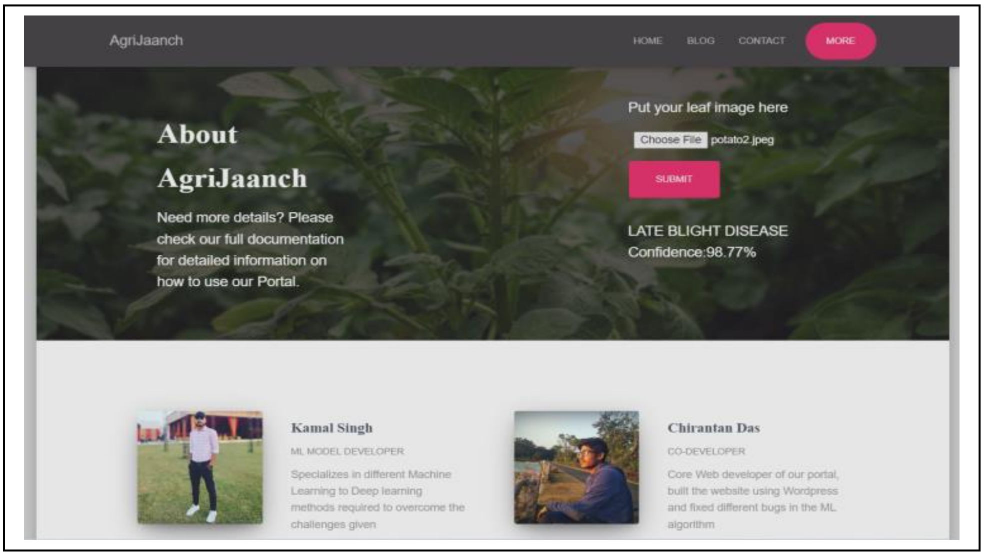

Fig. 3 Screenshot of the Web Portal of the Proposed Prototype 'AgriJaanch'

4. Implementation & Results

In this proposed model 2152 images of potato leaves were taken from a plant village dataset which comprises 1000 images of early blight, 1000 images of late blight, and 152 of healthy images of potato leaves. Table 1 shows the performance analysis through metrics such as Precision, Recall, F1-Score and Accuracy of our proposed CNN based DL model when the trainvalidate-test split ratios are 80:10:10 and 70:15:15 respectively. It can be easily seen that the best accuracy of over 99% is obtained. Table 2 provides a tabular comparison and Fig. 4 provides a plot-wise comparison of our proposed work with other published works available in literature on the basis of classification accuracy. It is observed that the results obtained by our proposed approach is 99.30% compared to the accuracy scores of 92% (Athanikar & Badar, 2016), 95% (Islam et al, 2017) and 97.80% (Tiwari et al., 2020).

TABLE 1: Train-Test Accuracy Analysis Table

			MODEL 1: 80% for Training, 10% for Validation, and 10% for Testing			**MODEL 2:** 70% for Training, 15% for Validation, and 15% for Testing		
Label	**Category**	**Samples**	**Precision**	**Recall**	**F1-Score**	**Precision**	**Recall**	**F1-Score**
0	Early Blight	1000	1.00	0.99	0.99	1.00	0.97	0.99
1	Late Blight	1000	1,00	0.99	0.99	0.95	1.00	0.98
2	Healthy	152	0.88	1.00	0.94	1.00	0.88	0.94
	Total = 2152		Accuracy = **0.99**			Accuracy = **0.98**		

TABLE 2: Comparision of Proposed Work with Previous Works (Tiwari et al.)

Model	**Classification Accuracy**
Image Segmentation + Backpropagation Neural Network [IS+BPNN] (Athanikar & Badar, 2016)	92%
Image Segmentation + Support Vector Machine [IS + SVM] (Islam et al., 2017)	95%
Image segmentation + Backpropagation Neural Network (using VGG19) + Logistic Regression [IS + BP + LR] (Tiwari et al., 2020)	97.8%
Our Proposed Approach	99.3%

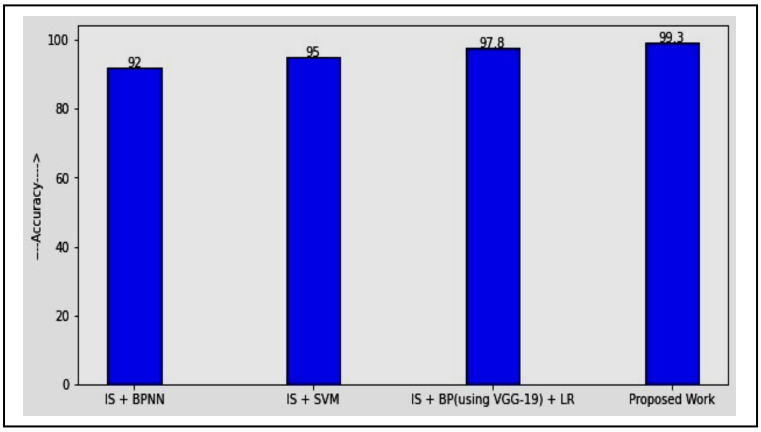

Fig. 4 Plot-wise comparison of Proposed Work with other Existing Works in terms of Accuracy

5. Conclusion & Future Scope

This research work implements and tests a plant-disease diagnosis method validated based on different image classifier baselines. However, some defects and difficulties include collection of a large labeled dataset, which is challenging. Although CNN gives much better accuracy due to unavailability of large datasets, transfer learning approaches have been introduced in plant disease classifications (Kodovsky et al., 2011). We can infer from the obtained result of 99.30% that our proposed system is very realistic and user-friendly as the only thing one really needs to do is just click an image of the leaf, fill in the plant's name and then AgriJaanch can easily detect the class of disease the particular plant has and thus it will be easily accessible to the common people.

In near future, we aim to upgrade our system by implementing the Treatment recommendation System where proper treatment required for the detected diseases based on the analytics including more plant species into action for which we require more machine power to handle such data load and we are working on a Mobile application as well which will be more user friendly as one will have to only click the picture of the image using the app and the detection system will do rest of its work.

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