A Convolutional Neural Network Based Potato Leaf Diseases Detection Using Sequential Model

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This Report Presented in Partial Fulfillment of the Requirements for

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APPROVAL

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We hereby declare that, this thesis has been done by us under the supervision of **Abdus Sattar, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

One of Bangladesh's primary agricultural products is the potato. In recent decades, Bangladesh has seen a surge in the popularity of potato farms. Nonetheless, farmer’s expenses in potato production are rising as a result of a number of illnesses. Nonetheless, the high cost of potato production is mostly attributable to a number of illnesses that are affecting the crop. Which is wreaking havoc on the farmer's schedule. In order to modernize the potato industry and speed up disease diagnosis, automation has been implemented. In spite of the claims to the contrary, potato leaf disease is a serious problem that can severely reduce crop yields. The leaves of diseased potato plants will show symptoms of early blight, Septoria blight, late blight, and other diseases. If such outbreaks are discovered at the initial level and enough intervention is done, the farmer will not be at risk of incurring significant economic losses. Based on the results of this study, a new model is presented for accurately identifying and detecting illnesses in potato leaf stands using image processing. While there are several methods that may be utilized in machine learning, the Convolutional Neural Network (CNN) model is what's being employed here to identify the disease in potato leaf photos. This work implements a CNN based sequential model to predict the disease of potato leaves. This research achieved 94.2% model accuracy on this model. The presented model was tested on both typical and disordered potato leaves in an effort to distinguish between the two. Next, the algorithm is applied to the images, and the potato tree’s leaf is classified as either healthy or unhealthy.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In terms of economic activity, agriculture is the backbone of Bangladesh. Crop production is the main source of income for the majority of the population in this country. Rice and potatoes are the most often consumed crops here. In certain areas, people don't have the money to buy expensive, nutrient-dense food all the time. Only once or twice a week do they splurge on gourmet cuisine. At other times, they ate a simple meal of rice and potatoes. Furthermore, they take other, nearly costless veggies. In contrast, potatoes are favored by this group because of the abundance of vitamins and minerals they provide [1]. It's high vitamin C concentration aids iron absorption, and it's an excellent source of iron in and of itself. Besides the B-complex vitamins and minerals (phosphorus, potassium, and magnesium), this food is a good source of pantothenic acid, riboflavin, and folate. Our diligent staff can put all these parts to good use. Potatoes typically yield around 18.08 tons per acre. Using cutting-edge technologies and caring for the crops better, we can boost output to 30–40 tons per hectare. The massive 2018 potato harvest is evident if we go back only one year. Table 1 shows the potato production in 2022 in India, Russia, United States. And China.

Table 1: Potato Productions In 2022

Country	Potato Production (millions of tons)
India	50.3
Russia	23.5
United States	22.5
China	49.6
World	370.8

Everyone knows what a potato is, and in many parts of the world it serves as a staple diet. The potato is sometimes considered the foundation of all veggies. It's common knowledge that potatoes play a sizable role in the Bangladeshi economy because of the country's status as an agricultural powerhouse [2]. As the world's number seven producer of potatoes, Bangladesh is a well-known and respected nation. The Department of Agricultural Extension estimates that a min of 0.90 and

a max of 1.19 crore tones of potatoes are grown annually on around 5 lakh hectares of land (DAE). Both the national budget and the agricultural economy benefit greatly from potato production. Because of rising global demand and the need to export as much as possible, potato production has become increasingly important [3]. But the reality is that in recent years the export and production level has decreased as a result of various significant diseases of potato leaf, such as early blight, bacterial wilt, brown spot late blight, Septoria blight, etc. In such a scenario, output would be severely affected. This is bad news for the farmers, who will also have to bear some of the costs. The potato leaf will sometimes show signs of the illness [4].

Occasionally, the plant's leaf will develop a spot. When a plant is infected with bacteria, the symptoms appear everywhere the plant is present. Septoria leaf spot manifests itself on leaves as a grey spot in the middle with a dark edge. Early and late blight are prevalent potato diseases. Small, black lesions are the most common sign of early blight, whereas the blistered, scalded appearance of late blight is easily recognizable.

It will be extremely helpful for farmers if a sequential model [5] is provided for identifying these diseases in potato leaves. Because photographs are the primary focus of this research, a sizable image database is necessary. There are three distinct processed picture options available. Early blight, healthy, and late blight are the three types. The total amount of images is divided in half, with the first half used for training and the second for assessment. Approximately 80% of the photos have used in the practice test, with the remaining appearing in the real thing. The suggested model would distinguish between healthy potato leaves and those affected by disease. Farmers may simply increase their expansion pace without risking a disease that could ravage a civilized civilization.

1.2 Motivation

It's safe to say that potatoes are one of the most important crops in our economy. In order to feed our working people for next to nothing, we need a massive potato harvest. We'll have to increase output to meet the increasing demand. And if we want to increase output, we need to give it a higher priority. Those many crop-damaging diseases are a major cause for alarm. Early blight and late blight are two widespread diseases that do considerable harm to our crops. When we get here, we'll be able to cut down on those illnesses, or at least identify the damaged crops and keep them apart from one another. Once again, when we pinpoint the causes of growth slowdowns and

implement fixes. Also, it is essential that the rapid expansion meet the demand. It's also really nutritious. For instance –

- Potatoes have been linked to a possible reduction in constipation and inflammation.
- There are 164 calories and about 30 percent of your daily B6 need in a medium potato.
- Minerals such as magnesium, iron, calcium, phosphorus, and zinc may be found in potatoes. Each of these components contributes to the body's efforts to preserve and strengthen bone tissue.
- The potato is an excellent source of the mineral's calcium, magnesium, and potassium. Patients with high blood pressure have found them to be extremely beneficial.
- Folate, which is found in potatoes, is essential for DNA synthesis and repair and also helps prevent many types of cancer cells from developing due to DNA mutations.

1.3 Research Objective

Our model was developed with the intention of detecting two of the worst illnesses early enough for preventative measures to be implemented. To determine whether or not crops are healthy, we employ a statistical model. If not, then what type of illness may it be? What stage of blight are we dealing with? We have amassed a large dataset from which our algorithm may draw insights and locate the anomaly as well as its source (which disease is it). Our model will be able to tell if the leaves are healthy or have been affected by early or late blight. With the use of a Convolution Neural Network, we were able to analyze photographs from any device and identify the condition only by visual inspection. And in a short period of time, it will naturally be effective.

1.4 Research Questions

Almost every mechanism has a complicated component that makes one wonder how everything operates. Problems arise that could have been avoided. If there are persistent problems, they must be fully explained and described. The questions that we follow from very start are-

- Which would be more appropriate for health monitoring: the roots or the leaves?
- What is the appropriate algorithms to detect the diseases?
- What are the data pre-processing method?
- Can we expect the utmost degree of precision?

1.5 Report Layout

The report has total 6 Chapters which will be followed given by instructions:

In Chapter 1, we have discussed about the introduction of this research in this part of this research, we discussed in details about the importance of potato leaf disease prediction. Research question, motivation of this research, rationale and expected output has also discussed in this part.

In Chapter 2, we reviewed existing work on leaf disease prediction in this chapter. We discussed about other authors approaches, limitations, results, methods in this part. Research scope and challenges also have discussed here.

In Chapter 3, research methodology has mainly discussed here. This chapter shows the data collection procedure, statistics of data, classifiers, figures of stats. Implementation requirements also have discussed in this chapter.

In Chapter 4, results of this research have mainly showed. In this chapter we have showed the result of all the classifiers we have used in this research.

In Chapter 5, shows how this research can impact in our society. Why this work is important and how it will sustain in this arena, this chapter shows mainly.

In Chapter 6, discussion and conclusion of this research have shown. In this part we have also discussed about the future work, and the limitations of this work.

CHAPTER 2

BACKGROUND

2.1 Introduction

We have a substantial proportion of our people dependent on the agricultural industry. Various crops are cultivated by them. Our climate is ideal for growing plants. However, problems exist for our farmers as a result of the same lack of knowledge. To improve the quality of the leaf photo, we employed a Convolution Neural Network. Specifically, we use a subset of deep learning known as CNN to accomplish our machine learning goals. Using our model, analyzing the photograph of the leaves will be a simple task. Farmers may easily identify sick crops using a simple analysis procedure. And that will aid in taking prompt action. Figures 2.1.1 and 2.1.2 show some sample images from the dataset that can serve as guides for our work. It's almost like having an instantaneous instrument at one's disposal to ensure successful harvests.

Fig 2.1.1 Healthy potato leaves

Fig 2.1.2 Unhealthy potato leaves

2.2 Related Works

Several recent studies have contributed to the classification of leaf diseases. Here, we take a look at the several methods for detecting illness that have been studied by various researchers.

Based on the leaf structure used to identify potato mold, this article calculated the proportion of the wavelength of sunlight across that's absorbed in the spectrum. Automatic Image Segmentation Using Deep Neural Networks. Once models are functional and able to differentiate between bays and spectra, illnesses were assessed separately using greenhouse research spectra with an accuracy of 84.6%. In addition to the 92% accuracy of leaves, further 3 types of recently blight wound development are also taken into account. The model achieves a 74.6% accuracy rate when classifying fake pre-marked leaves, fake healthy trees, and fake black-crowned trees [6].

They present methods for diagnosing from leaf images using act image processing and machine learning in this paper. Recent advances in phenotyping and disease diagnosis represent decisive strides in achieving food safety and property agriculture. Automatic illness classification using image data from the public Plant's Village database is a common practice. With the help of a segmentation strategy and several support vector machines, we were able to correctly label 300 images of various illnesses [7].

Using a combination of process and machine learning-based automation systems, this article paints a picture of how illnesses affecting potato leaves are gradually being identified and categorized. In this paper, we present the results of a large-scale image classification task in which 450 images of healthy and diseased Potato leaves were collected from publicly available plant villages Databases and 7 classified methods were used for recognition and classification of the images; among these, Irregular Forest Classifier provided the highest accuracy at 97% [8].

In this research study, the authors provide Transfer Learning Technology, which can be used to identify potato mold at an early stage, even when it is difficult to collect images of thousands of most recent pages. To tackle fresh problems, deep learning models may be transferred from one problem to the next using the transfer learning technique. 152 normal leaves, 1,000 blighted leaves, and 1,000 early-stage blight leaves were photographed as part of the tests. The Blight Page algorithm forecasts with 99.43% accuracy. Knowledge was tested to the two hundredth and eightieth iteration [9].

The study of crop disease forecasting has made extensive use of machine learning, SVM, RGB image analysis, and many other machine-learning techniques. In addition, Islam et al. have used a multi-class model using Support vector machine to make diagnoses of potato disorders. Three hundred photographs of the model were taken. The performance of the model investigator has been measured using a variety of operational characteristics, including sensitivity, accuracy, F1-score,

and recall. A deep Convolutional Neural Networks model, taking apple and tomato flora into account, was developed by Sladojevic et al. Researchers utilized the technique to distinguish between 13 distinct diseases when comparing healthy and damaged leaves. To differentiate between 25 disorders, Ferentinos et al. employed AlexNetOWTBn's deep learning framework in conjunction with VGG. Tomato plant disease diagnoses were recognized in real time using a Region-based fully convolutional network, as well as Regions with deep neural networks and a Solid-State Drive [10].

Many scientists not only trained their models on the Plant Village dataset, but they also focused on illnesses that affect potato crops. Khalifa et al. proposed it et al. to use a convolutional neural network (CNN) to distinguish between healthy plants and those infected with early and late blight. The Plant Village dataset was used to train the model, which is limited to crops grown in specified areas. When it comes to diagnosing potato diseases, Rozaqi and Sunyoto advocated for the use of a convolutional neural network (CNN) model. The Plant Village dataset was used for model training in order to identify regional illnesses. To identify both diseased and healthy leaves, Sanjeev et al. presented a Feed-Forward Neural Network (FFNN). The Plant Village dataset was used for both training and testing the suggested technique. To identify early blight, late blight, and healthy classes in potato leaf images, Barman et al. developed a self-built convolutional neural network (SBCNN) model [11].

2.3 Scope of the problem

Our model's job is to identify crop health and disease. Our program can notify farmers in real time if early or late blight attacks an agricultural field. We needed a methodical approach if we were going to succeed at this. But there are problems with such plan of action. Some late blight statistics are too similar to early blight data. Some leaves are infected, but the level of infection is too low for easy detection. Our approach has the potential to be confused with a wide variety of different diseases. The images of potato leaves may be processed with an accuracy of 94.2% using a Convolutional Neural Network (CNN) model classifier. Our model has given us hope as well.

2.4 Challenges

Using the model that we have developed; our goal is to obtain the highest possible degree of precision. It will be more useful and advantageous for us to obtain as much of it as we can. We require a large dataset with a high-quality complete image in order to improve the degree of accuracy we achieve. The fact that our data collection comes from a variety of villages represents one of the difficulties we faced while conducting this study. Once again, they have trouble making an accurate comparison between the two disorders. Because our model encompasses both the early and the late stages of the blight. And by studying the young leaves, it will be possible to determine whether crops are healthy.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This section of the paper serves as an outline of our thesis and the methods we used. It provides us with comprehensive data and actionable tactics. For our purposes, this means pinpointed application and actualization. It will do the same thing for the credibility of our data collection efforts. It will demonstrate how we want to use those to the categorization of leaf diseases in potatoes. The research methods and tools will be covered here.

3.2 Research Subject and Instrumentation

We're investigating this to find a more reliable approach to disease classification in potato leaves. We decided to dissect some images to see whether the leaf is changed in order to finish it. Potato production in Bangladesh is on the rise. The majority of farmers in the United States lack formal education. There is frequently difficulty in diagnosing potato illnesses. It's really hard to tell a diseased potato leaf from a healthy one just by looking at it, because the symptoms of different illnesses can be very similar. Lacking accurate diagnosis, appropriate therapy cannot be administered in such instances. The crops and soil might be harmed if we choose to treat a certain ailment with an alternative therapy. Maybe the soil's fertility will drop, nothing will grow, and farmers would lose a lot of money. Because of these considerations, we have settled on this as our area of study. Convolutional neural networks (CNNs) may be used to build a neural model that filters out irrelevant image sources and translates them into correlations with quality ratings. They provide a unique space for several neural networks that may be constructed to accommodate the essential problems encountered during the request process. Before comparing them to more conventional approaches, they need to be dealt with so that more methodical deliveries can be made, yielding a more successful implementation. We've experimented with several different kinds of intensive reading formats in service of our ultimate objective of preventing potato illness.

3.3 Data Description

Collecting relevant data is essential in any study. In this case, an authentic data set can be really helpful. We've taken images of the potato fields in the village to supplement the data we've gathered from open-source datasets. Around 3561 photos across three categories were discovered in the database. All downloaded images are saved in a space-saving JPG format, and their color spaces are all calibrated to the RGB standard. The percentage of gathered data that contains late blight, early blight, and healthy data for potatoes is illustrated in Fig. 3.3.1.

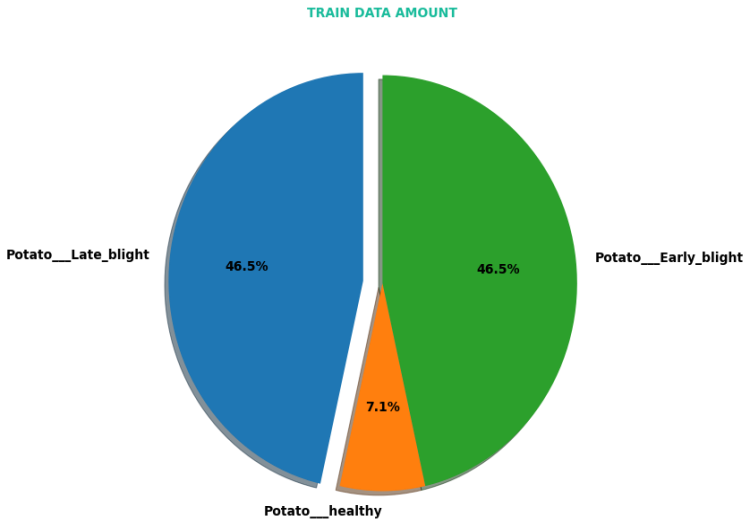

Fig. 3.3.1. Data Ratio

As a whole, the resolution of the photos in this collection was determined to be somewhat poor. Because of this, the sound was not altered before being played. In order to shorten the time, it takes to complete a training cycle, the photos in the database were downscaled to a resolution of 60 by 60. Speed up training with this method of measuring specifics or things of interest. This is achieved by enhancing the mathematical status of the development issue. It was also established that some of the erroneous assumptions made about the beginning and finish were correct. Essentially, the goal of this study is to apply standard implications and variations to image ratings in order to locate all pixel respects with a comparable access. Z-score is the common name for this metric in the field of AI. In the following figures 3.3.2-3.3.4, shows the sample picture of collected dataset.

Fig. 3.3.2. Leaf of Potato Early Blight

Fig. 3.3.3. Leaf of Potato Late Blight

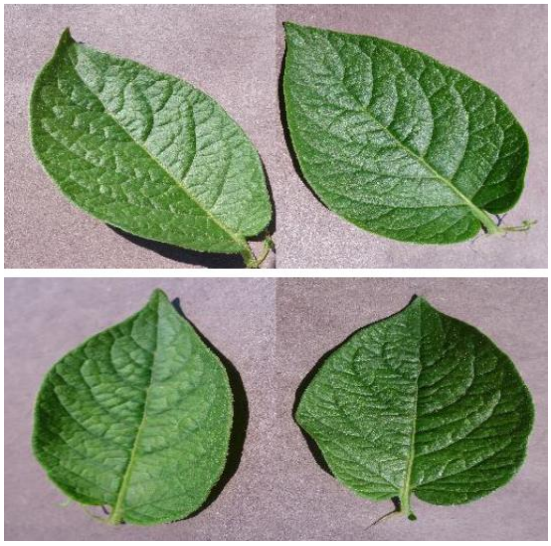

Fig. 3.3.4. Healthy Potato Leaf

A few samples of the information gathered are shown in Figures 3.3.2-3.3.4. In this research, photos were compiled from each of these three classes for three categorization and preprocessing.

3.4 Statistical Analysis

Low-resolution versions of the photos in this collection were discovered. As a result, no preprocessing was applied to the final audio product. To save training time, the photos in the database were scaled down to 60x60 pixels. Incorporating a method for assessing specifics or objects of interest into the training process will reduce the overall time required. Specifically, this is achieved through enhancing the mathematical status of the development issue. Several erroneous assumptions about the beginning and end were also verified. We propose a system of rating images in which standard implications and deviations are used to locate all pixel regards with a comparable access. Z-score is the word used when talking about this in the context of AI.

3.5 Proposed Methodology

With the use of a CNN, a personal computer model may be developed to filter out irrelevant image sources and transform them into correlations with output grades. Each of their many neural organizations has its own dedicated space, so it can be tailored to address the key concerns of a

given request. Prior to being compared to conventional methods, they need to be managed so that methodical deliveries can be made that result in superior performance. We have tried a few different approaches to learning that work from the ground up in order to get a clear picture of the tomato landscape.

The sequential model is built with the help of the CNN algorithm [12]. Keras provides step-by-step support for the model's construction; for example, the model includes a Convolution two-dimensional layer to deal with photos and image input size (256,256), albeit this layer may be scaled to accommodate images of any size. Within the dense layer, which connected the two-dimensional convolution layer, there was a flat layer that served as a bridge between the two. Rectified linear units (ReLU) are employed as a functional enabler in this approach. SoftMax, presented as an activation in framework for making predictions based on maximum likelihoods, is one such method. The following is the equation for the SoftMax function:

$$P(x) = \frac{e^{x^T W^l}}{\sum_{k=1}^{k} e^{x^T W^l}} \qquad (1)$$

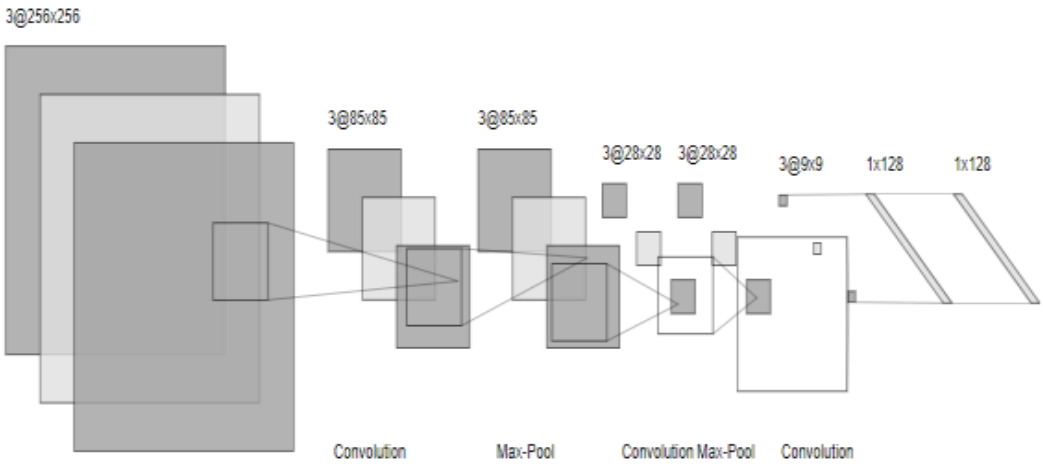

Fig. 3.5.1. Sequential Model Diagram

The highlight-smashing convolutional layer puts that capacity to work. The remarkable quality of the individual parts grows as the ascent progresses from beginning to conclusion. While the number of LTER studies is growing rapidly from one square to the next, the channel size remains fixed at 2 by 2. On the block, the highest possible LTER number is 66, and all other numbers are

unchanged. This increase in the number of terms LTERs is crucial in reducing the size of the guides of things brought about by the use of total layers in all squares. The object mappings are also layered with zero to keep the image size the same once the convolution algorithm has been applied. By using the top integration layer, we are able to reduce the size of the object mappings, shorten the time it takes to be ready, and better account for variations in the data. The max-pooling piece is a square, with dimensions of 2 by 2. In disconnected introduction, the ReLU enactment layer is used on all blocks. Additionally, a Dropout production method has been created, which has the possibility to save 0.5, to keep the tactical distance from the train same. In the midst of a time of intense focus on making preparations to lessen model disparities and simplify the structure in order to prevent overcrowding, the act of dropping a random act calms anxieties throughout the organization. At last, a block made up of two structures has been fully incorporated into the layers of both the 500-nerve and 10-nerve neural structures.

3.6 Proposed Model Workflow

In order to effectively diagnose potato leaf disease, a variety of actions must be taken. Following Fig. 3.6.1. is the block diagram which is the proposed model workflow of this work.

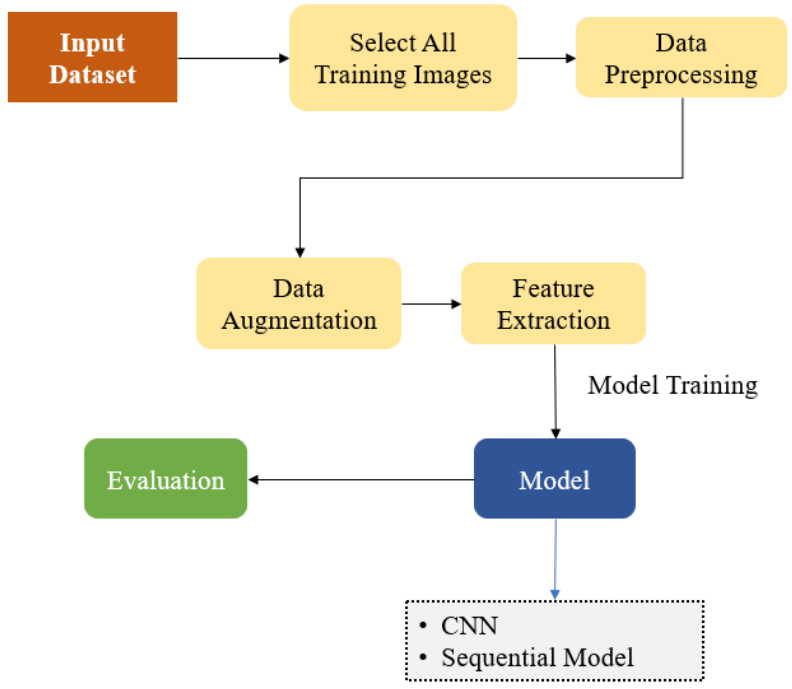

Fig. 3.6.1. Proposed Model Workflow

3.7 CNN

A neural network is a collection of algorithms that attempts to replicate the way the human brain works in order to discover latent links in a dataset. Here, "neural networks" refer to any system of neurons, whether biological or synthetic. An in-depth analysis the three layers that make up a convolutional neural network (CNN) are a convolutional layer, a pooling layer, and a fully connected (FC) layer. In a deep neural network architecture, the convolutional layer comes before the FC layer. The FC layer is the next most complicated layer in the CNN after the convolutional layer. This escalating complexity is what enables the CNN to gradually recognize more and more complex aspects of a picture, ultimately identifying the object in its whole. CNN uses a hybrid of monitored and unmonitored learning architecture. You may make predictions and categorize using them. Yet CNN mostly relied on a supervised procedure. CNN uses a number of criteria to determine how to categorize a given set of images. To do this, CNN uses activation functions to calculate possible maps. You may find the formula [13] for the function in the following:

$$y_i^l = f(z_j^l) \qquad (2)$$

Where, y_i^l is called forthcoming graph, & $f(z_j^l)$ is called

activation function. To process documents, convolutional neural networks (CNN) use two-dimensional convolution processes.

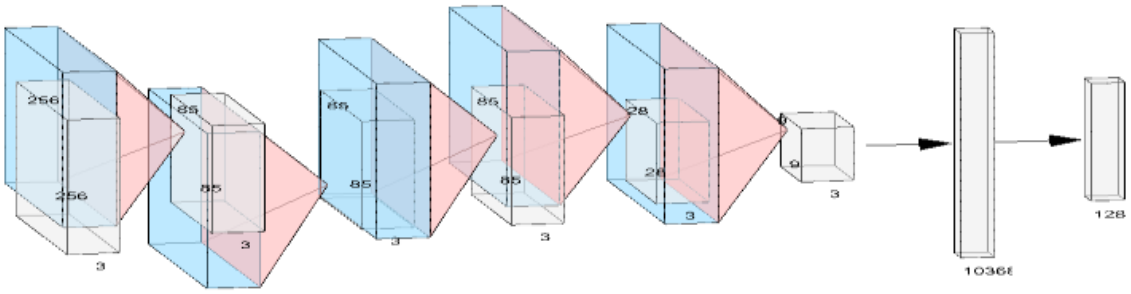

Fig. 3.7.1. CNN Structure

Fig. 3.7.1. illustrates the model's fundamental CNN structure by depicting the surface, lining, height, depth, and thickness of the components that make up the model [14].

3.8 Model Compiling

The "adam" optimizer is used. It's a great tool for optimizing the training process by adjusting the learning rate at any time. In order to facilitate the implementation of our loss function, we employ "categorical cross-entropy" for training the system and incorporate a "accuracy" measure for representing the average accuracy on the validation set. The model is trained using the fit () function. Examining the reliability of the validation data set. The fitting function that fits the system across the data specifies the number of epochs. Following the completion of the training process, the testing method may be set up. It validates the potential of the trained CNN model.

3.9 Implementation Requirements

There are some requirements to implemented this project.

Hardware or Software Requirements

- Windows 7 or above operating system
- Portable or in-built Hard Disk above 300 GB
- Minimum 2 GB RAM
- Google Chrome or Mozilla Firefox

Developing Tools

- Python with Tensor flow
- Jupiter
- Notepad++

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

Specifically, the descriptive analysis of the data utilized in the research, as well as the experimental outcomes of our project, are the primary emphasis of this chapter 4. It is important to give every possible method or theory a go. Nothing beats exercising sound judgment and putting it to the test. By employing my suggested strategy as a dynamic framework, we have been able to put our vision to the test. This section of the report manages the internal and external significance of the framework we used. This section also demonstrates the casing's initial and final limits of construction.

4.2 Experimental Results

There was a wide range of metrics employed by writers to evaluate the efficacy of their models. While most studies utilized a combination of markers to evaluate success, a few relied on just one. We evaluate this study using the accuracy, graph, and confusion matrix. In the first place, this study develops a 7-stage CNN sequel model. By tracking performance errors using Adam Optimizer and fine-tuning cross entropy. To finish the model, we employ transfer learning. For this purpose, we rely only on the keras library and its associated apps, which supply us with pre-trained weights. By removing the final few layers and adding some Junne lavens, we were able to adjust the Deep Learning model so that the which was before weights were appropriate for the output dimension. In this work 20 epochs have been worked and the following Fig. 4.2.1. And Fig. 4.2.2 shows the graph between accuracy vs epoch and loss vs epoch.

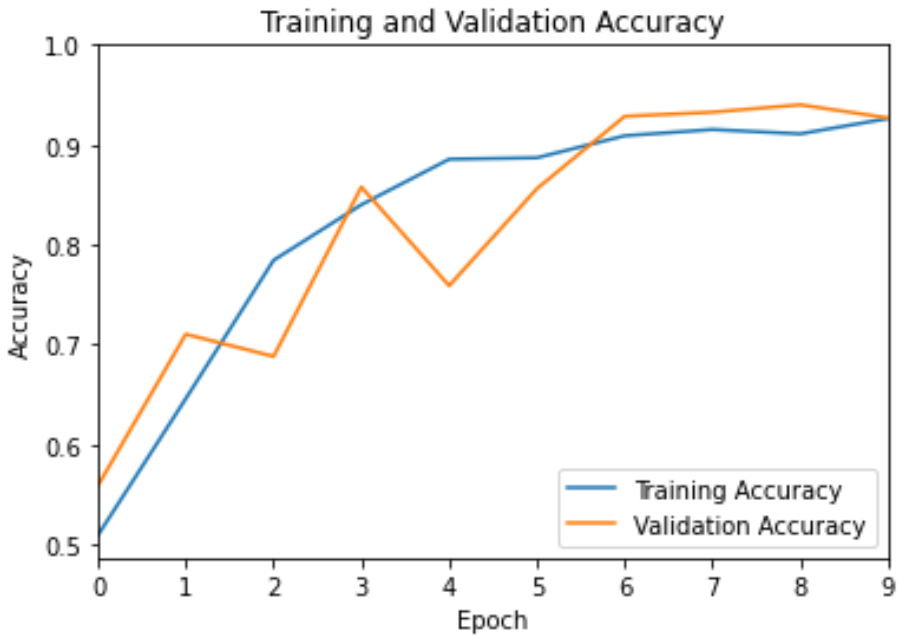

Fig. 4.2.1. Accuracy vs Epoch graph

Fig. 4.2.2. Accuracy vs Data Loss graph

After evaluating the model, this work has performed well. CNN have achieved 94.2% model accuracy. Table 2 shows the performance of this work.

Table 2: Performance of CNN

Algorithm	Accuracy	Precision	Recall	*F*1-Score
CNN	94.2%	0.73	0.80	82.3%

4.3 Discussion

As a means of describing the efficacy of a classification method, confusion matrices have become more popular. If there is a significant imbalance between the number of observations in each class or if there are more than two classes in your dataset, relying just on classification accuracy may be deceptive. You may learn more about the strengths and weaknesses of your classification model by calculating a confusion matrix [15]. As an optical representation of an algorithm's output, the confusion matrix is a useful tool. Correct and incorrect assumptions are weighed and compared. The following are examples of the accuracy [16] in the model equation and the precision of the classification rate equation:

$$\text{Accuracy} = \frac{\text{TP+TN}}{\text{TP+FP+TN+FN}} \qquad (3)$$

Here, TP= True Positive, TN= True Negative, FN= False Negative, FP= False Positive.

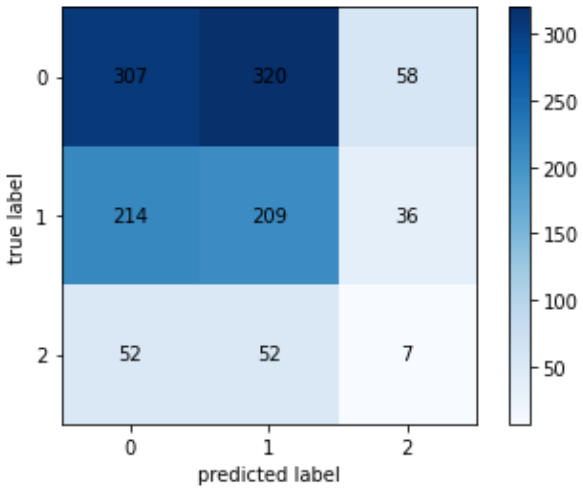

Fig. 4.3.1. Confusion Matrix

As seen in Fig. 4.3.2, our classification model is represented by a confusion matrix. That's because the greatest across gain occurs in Row 1. Because of this, the method we provide will provide the highest precision possible.

The Google collab notebook serves as a repository throughout the entirety of the process. In the initial step of the process, several pictures of septic potato leaves were computed in order to classify them. The photographs are chosen from within the folder that contains the dataset. After the photographs have been uploaded, the results of the forecast are displayed.

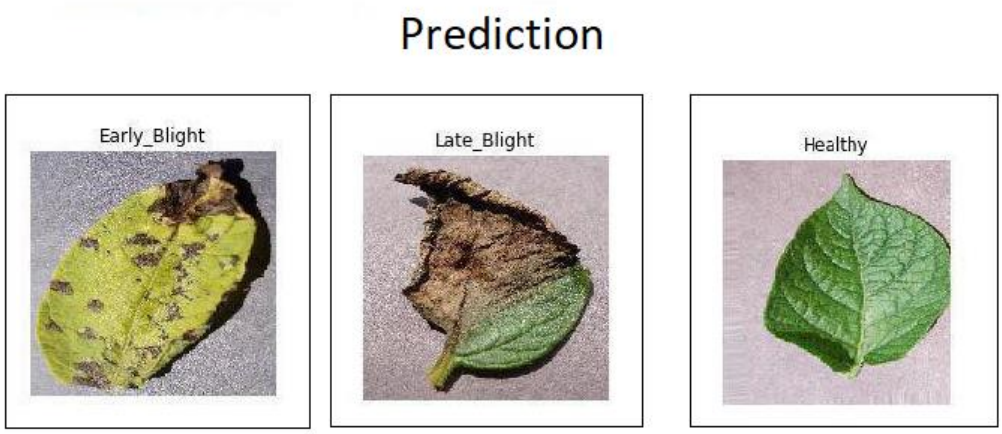

Fig. 4.3.2. (a) Early Blight, (b) Late Blight, and (c) Healthy

Fig. 4.3.2. (a) demonstrates that Early Blight have impacted the leaf. It is common to observe a circle that is golden or bright green-yellow in color and overflows the dots. When the dots grow to be very large, they might cause entire leaves to turn yellow and die. This can happen when the spots reach a certain size. The late blight may be seen to have an effect on the leaves as seen in Fig. 4.3.2 (b). The first signs of leaf flecks appear as very little, light to dark green dots with an uneven form. When the temperature is chilly and damp, the flecks quickly expand into vast regions that range in color from brown to a deep purple. It's possible that the illness could eat the leaflets in their whole or that it will go down the branchlets and into the stem, ultimately destroying the plant. Finally, Fig. 4.3.2. (c) depicts the leaf in its healthy state. As a result, the photos that are unhealthy and those that are healthy may be precisely identified by this algorithm.

This research was focused on to identify the potato leaf disease. After implementing CNN algorithms in sequential model, the model works well in this dataset. This research works better than some previous works that already have mentioned in the literature review section.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT, AND SUSTAINABILITY

5.1 Impact on Society

Potatoes are a staple food in many cultures throughout the world. Despite its status as a side dish in the West, this meal is almost a staple in Bangladesh. Rice used to be quite expensive in Bangladesh. And the poor had no choice but to suffer since they could not afford to buy rice at the inflated price. At the time, the impoverished could not resist buying potatoes because the price was so low. Then potatoes actually assist them to live. Potatoes were substituted for rice because of their low cost. Naturally, the abundant potato harvest that year accounted for its low price.

Again, potatoes are utilized to perform many more things. Potatoes are used in the production of several alcoholic drinks. Potato starch is widely used in the culinary business as a binder and thickening, especially in soups and sauces. People in many Asian nations enjoy potatoes in a variety of forms and use them often in cooking. Predicting potato leaf disease in this study can aid the agricultural sector.

5.2 Impact on Environment

Glycoalkaloids, a class of poisonous substances, are abundant in potatoes. Solanine and chaconine are the two most common alkaloids. Specifically, this. Tomatoes and eggplants are members of the "Solanaceae" family of plants, which also includes henbane, tobacco, and deadly nightshade. The leaves, flowers, sprouts, and seeds of the potato plant are where you'll find the highest concentration of the substances that help defend it from predators.

Many studies on plants have utilized potatoes as a model. Because of its parenchyma tissue and the ease with which potatoes can be cloned, it serves as an excellent "model tissue" for scientific study due to its low metabolic activity and its versatility. Studies on the wound-response properties of potato tuber tissue are typically followed by electron transport tests. This is because potato tuber tissue is chemically and morphologically comparable to "standard" study organisms like Escherichia coli, Caenorhabditis elegans, and Drosophila melanogaster.

5.3 Ethical Aspects

This research work must respect every user’s security & privacy. All the data have collected manually by our researchers. There is no previously published data have used in this research. The results we have provided are correct. There is no false information regarding this research. No animals were harmed during our research. All the members of our group helped equally and we walked with our supervisor's guidance.

5.4 Sustainability Plan

We are aware that identifying diseases on leaves is an extremely vital aspect of every nation. It has the potential to assist in the prevention of illness in the agricultural business. This is a process that goes on indefinitely. The potato is one of the most widely consumed vegetables. This research has to be helpful to farmers in order to avoid potato leaf disease. This research will, without a shadow of a doubt, endure for a very long time in the realm of technology. In the future, we want to enhance the accuracy as well as the data range. In the future, we want to use more algorithms in order to compare and determine which one provides the highest level of accuracy.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Summary of the study

Following the completion of the investigation, we came to the conclusion that it is of the utmost significance for individuals to manufacture an adequate quantity of things. Because it is physically impossible for a human to go without eating, and because maintaining a healthy lifestyle requires following an appropriate diet, having access to high-quality food is essential to doing so, In this case, potatoes provide an abundance of beneficial nutrients. And it is able to supply a great deal of energy. Therefore, there is a very high demand for potatoes among individuals. It is also used to manufacture a wide variety of dry meals, which may be stored for an extended period of time. And the youngsters like it a great deal. Therefore, an increase in the production of potatoes might bring about a more significant shift in our dietary practices. The findings of this investigation point to a solution for avoiding the issue.

6.2 Conclusions

The primary goal of this study is to develop a machine learning method for disease identification in potatoes on any surface (CNN). From the results of this study, it is clear that CNN is the method of choice for detecting objects of this kind. But the validation accuracy of this model improves to 94%. This study runs on a combined dataset that is both new and old. An initiative like this has the potential to significantly benefit agricultural industries worldwide. Most of the village's farmers in Bangladesh are illiterate, so they lack the information they need to successfully combat the illness. You can't let them in on the secret of how to spot sickness. It's because of this insect that our potato crop is being wiped out, and our farmers are the ones bearing the brunt of the consequences. The lives of potato farmers in Bangladesh might be improved thanks to this study. The accuracy of the model and the data used are the work's main flaws. More data can help improve accuracy. In the future, we hope to develop an android app that can identify problems in any type of crop and prescribe effective treatments for such diseases. In the future, we can gain improved

accuracy by expanding this database. In order to further the progress made thus far, this study will involve the creation of an android app. Moreover, we will establish a mechanism through which afflicted farmers in Bangladesh will be able to quickly and conveniently get assistance and guidance in the form of disease detection.

6.3 Implication for further study

For this research we have recommendations. Machine learning classification is being used in my work for developing accuracy of the model. For a large number of datasets there are many algorithms and methods, datasets. So, that model will predict more exactly for potato disease detection. In future we will -

- Improve accuracy.
- Apply more ML models
- Improve dataset
- Weather based result prediction.

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