POTATO LEAF DISEASES DETECTION USING CONVOLUTIONAL NEURAL NETWORKS

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**POTATO LEAF DISEASES DETECTION USING CONVOLUTIONAL NEURAL NETWORKS**", submitted by Dil Tabassum Subha, Farid-Uz-Zaman and Anik Biswas to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation will be held on 31ST MAY 2021.

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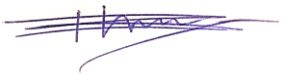

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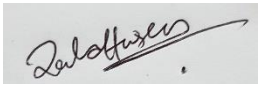

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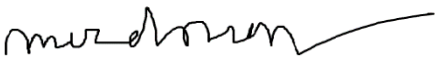

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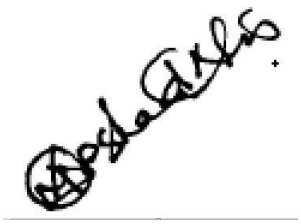

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DECLARATION

We therefore, declare that we have done this project under the supervision of **Warda Ruheen Bristi, Lecturer, Department of CSE,** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

We know that the root of the potato tree is used as a food in many countries of the world. It is called potato. Scientific name is "*Solanum Tuberosum*". It is from the Solanaceae family. The Solanaceae family prefers cool weather to grow. The best is between 15 to 18 degrees and required PH for soil is 5.5 to 6.0. More temperature can make an effect for growing in tropical Africa, potatoes are cultivated in high lands about 1500 to 3500 meters above sea level. The year "2008" was celebrated as "international potato year" which was organized by a United States organization dated 18th October, 2007. The sector of agriculture has been now a key backbone to Bangladesh's economy. Bangladesh has a large population who take potato as a side meal with "Rice". As potato cultivation is huge it has several diseases. The most common is late blight and early blight. It is quite tough to detect potato's disease from sightseeing. That's why we used different kinds of sensors for detecting those diseases. Detecting those diseases through AI we can find an easy solution. And also it will help our farmer to take necessary steps in time. And they will be able to grow as their target. To grow healthy crops, we need to find out the problem, to maintain the health of the food. And by using technology now it is very simple. Here we decided to use convolutional neural networks. It is a class of deep neural networks, in deep learning, which is applied commonly to analyzing visual imagery. We will use the image of potato leaves to analyze if it is healthy or not.

In this segmentation approach and utilization of support vector machines demonstrate disease classification over 2152 images with an accuracy level of 98.29%. Thus, our proposed approach presents a path toward automatic disease diagnosis of plants on a great scale.

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CHAPTER 1

Introduction

1.1 Preface

Our country “Bangladesh” is an agricultural country. General people of our country earn their livelihood through growing crops. Among all these crops rice and potato are mostly popular. We have a poor population who can't always buy rich food. They eat rich food once or twice a week. And the other time they used to take plain rice with potatoes. They also take some other vegetables which are almost free of cost. But for them, potatoes are most preferable because they contain a lot of vitamins, minerals. It’s also a good source of iron, and its high vitamin C content promotes iron absorption. It contains vitamins B1, B3 and B6 and also contains minerals such as phosphorus , potassium and magnesium, and contains pantothenic acid , riboflavin and folate. All these components are very useful for our hardworking people. The average growth of potato is 18.08 ton per hectare. The production can be increased up to 30-40 ton per hectare using modern technology and improving the health of the crops. If we look back to 2018 we can see the huge amount of potato production.

Table1: potato production in 2018

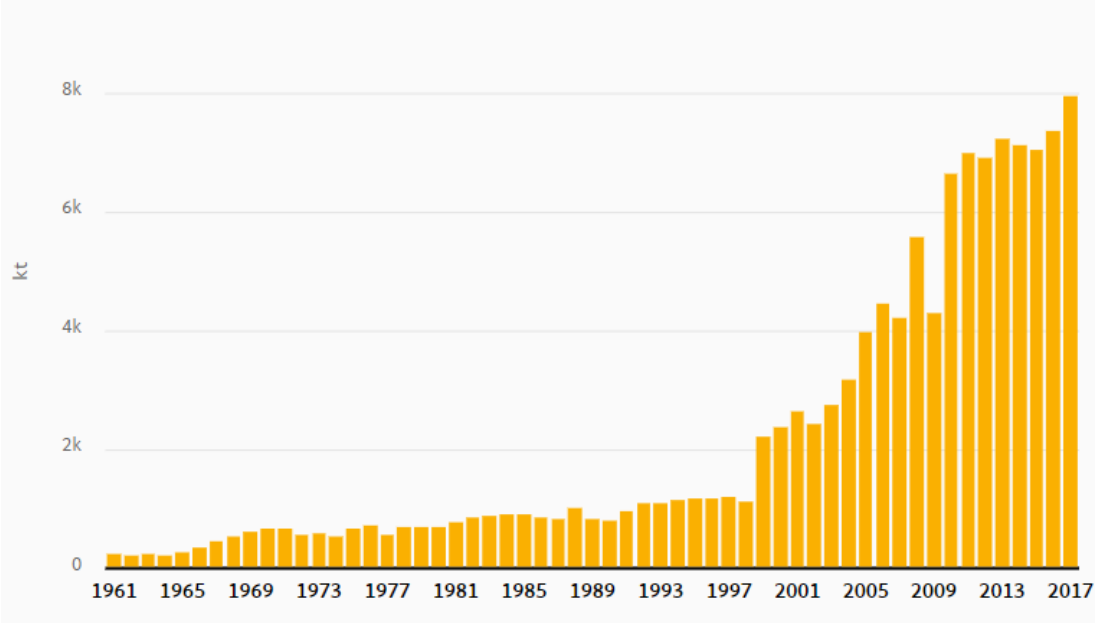
Country	**Production (millions of tons)**
Ukraine	22.5
Russia	22.5
United States	20.6
China	98.3
India	48.5
World	**368.2**

Early blight and Late blight are the most popular diseases of potato. It makes the crops unhealthy and also decreases the production. If production is decreased there will be a shortage of potatoes. People who are too poor to buy healthy food, will face big trouble. By using modern technology it's now very easy to detect healthy crops. And that will increase the production of the potato.

1.2 Motivation

Potatoes are a major food product in our country. To maintain the minimum diet of our working people at almost free of cost we need a huge production of potatoes. The following table show the rising demand of potato-

Table2: Total potato consumption of Bangladesh from 1961 to 2017



Historically, in 2017 total consumption of potato in Bangladesh reached 7,968 kt, which is an all-time high. On the other hand, in 1964 an all-time low of 241 kt. When compared to

Bangladesh's main peers, total potato consumption in China amounted to 61,980 kt, 34,181 kt in India and 421 kt in Myanmar in 2017.

To fulfil this rising demand we need to increase our production. And to produce more we need to be more concerned about it. And the matter of concern is those different kinds of disease that make our crops unhealthy. There are some common figures, such as early blight and late blight that cause huge damage to our crops. When we come toreduce those diseases or at least by identifying the affected crops we can separate them so that they can't spread disease.

Again when we will identify and take proper steps that will improve the growth. And it's a must that the high growth will full-fill the need. Also it has a large amount of food value. Such as[1]-

- There is some evidence that suggests potatoes might help to reduce constipation and inflammation.
- A medium sized potato contains almost 30% of the recommended daily B6 intake and 164 calories .
- In potatoes there are magnesium, iron, calcium, phosphorus and zinc. Those all ingredients help the body to maintain and build our bone structure and strength.
- Calcium, magnesium and Potassium are all present in the potato. These have been found very helpful to the patient of high blood pressure naturally.
- Potatoes contain folate which plays an important role in DNA synthesis and repair, and it also prevents many types of cancer cells from forming by mutations in the DNA.

By keeping all these things in mind we set up our work plan.

1.3 Objectives

We designed our model to relate with two of the most harmful diseases to detect them so necessary steps can be taken in time. By our model we will detect if crops are healthy or

not. If not then what kind of disease is it? Is it early blight or late blight. We have collected a huge data set from which our model can analyze and detect the spot and the reason for the spot (which disease is it). As we are working on early blight and late blight our model will be able to detect those or otherwise the leaves are healthy. We used a Convolution Neural Network that will process images from any device and by analyzing the image the disease can be recognized. And of course it will work within a short time.

1.4 Research Questions

Almost every system has a complex part and these parts raise the question of how the work is done. Some issues are created that should have been solved. When there are some regular issues they have to be justified and also have to be characterized perfectly. The questionnaire that we follow from very beginning are-

- What will we choose for health detection, root or leaves?
- From which source we will collect our data set ?
- Which algorithm will we use?
- How will we execute our model?
- Will it be possible to achieve the highest accuracy level for us?

1.5 Expected Outcome

Overall, our proposed model covers four significant steps:

- Data collection
- Data pre-processing
- Classification
- Finally, decision making.

CHAPTER 2

BACKGROUND

2.1 Introduction

A large population of our country lives on agriculture. They grow different kinds of crops. Our environment is good for cultivation. But our farmers also face difficulty because of the lack of awareness. We used the Convolution Neural Network to process the image of the leaves. Here we work with machine learning, and CNN is a class of deep learning. Our model will be an easy process to analyze the picture of the leaves. And by an easy analyzing method farmers can be able to find out the unhealthy crops. And that will be helpful to take quick steps. There are examples of pictures with those we will work at Fig2.1 & Fig2.2. It will be like a doorstep tool to help them for good crops.

Fig2.1: healthy leaves

Fig2.2:unhealthy leaves

There we have our steps in the knowledge Discovery process.

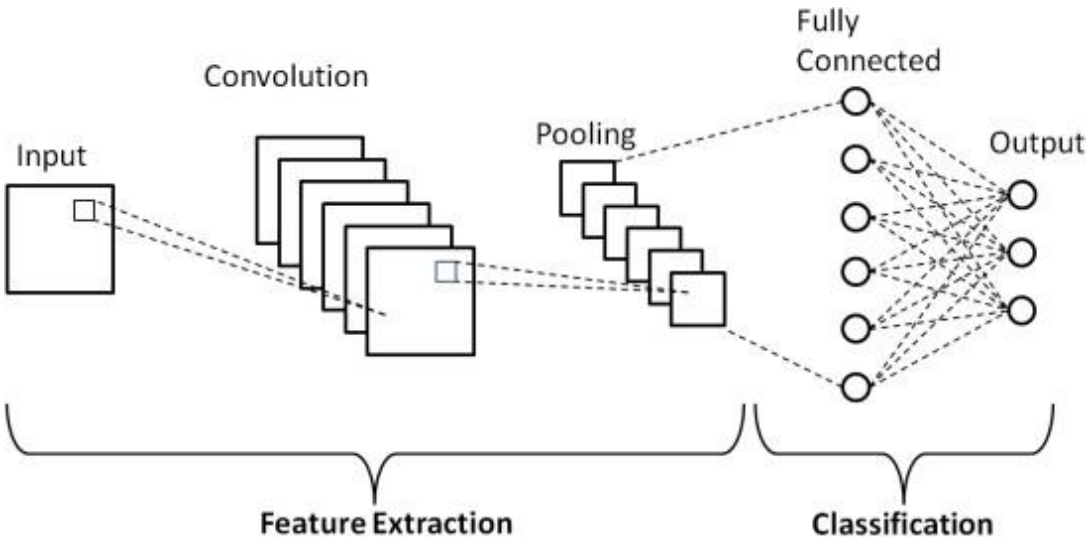


Fig3:CNN process of our model

2.2 Related Works

Here we start to find out something new. To do that we have to gather ideas about previous working methodology. It's almost a common sector in our farming. There are several works on crop health detected by leaves. It is now very much popular and easy to detect diseases by image processing of crops leaves. Here we focused on some previous work.

- A review of early blight of potato: By J E van der Waals, L Korsten & T A S Aveling.
- A Model for early detection of potato late blight disease: a case Study in Nakuru County by Toroitich Patrick Kiplimo.
- Detection of potato diseases using image segmentation and multiclass support vector machine: By Monzurul Islam, Anh Dinh, Khan Wahid, Pankaj Bhowmik.
- Status and symptomatology of early blight (Alternaria solani) of potato (Solanum tuberosum L.) in Kashmir valley: By S. A. Ganie, M. Y. Ghani, Qazi Nissar, Nayeema Jabeen, Qaisar Anjum, F. A. Ahanger and Aadil Ayaz.

2.3 Comparative Studies

[1] Author proposed a method to present significant help in the storage period and it is a helpful tool that prevents damages in growth. An early problem recognition is difficult in that kind of case. They generated the ANN model, which is characterized by repeatability and objectivity of evaluation. They designed their model to adopt a mobile application in a mobile device.

[2]Here the author discusses both tomato and potato leaves, and makes a comparison between them. After researching extensively on the A. Solani Pathosystem on potato and tomato it was decided, various aspects remain that need to be investigated. They claim that epidemics increase mostly after a strong sandstorm, due to the high amount of bangs of the cuticle (Rotem & Reichert 1964). The infections at the primary level emerge with pale halos.

[3] Nakuru County produces potatoes for both domestic and commercial use as one of the leading producers. They used Arduino UNO. Farmers in the area depend heavily on human vision for identifying potato's disease. Farmers use uncertified seeds routinely for planting. They recycle seeds and use uncertified seeds to be susceptible to potato late blight disease. They find out the disease and do as steps needed. They became able to grow more by developing the method.

[4] They choose a method based on a set of masks that was created by color and luminosity components analysis of the different regions of the picture. Their image segmentation with multiclass SVM is used to develop a freely accessible and automated system. The most serious diseases in potatoes are late blight and early blight are detected with a little analyzing exertion. Their approach offered farmers an efficient, timesaving and feasible way of disease identification.

[5] Here authors focus mainly on Pathogenicity tests. fungus which are the morphological characters isolated from potato leaves, were studied on potato dextrose agar medium. The disease symptoms don't appear if the case is of uninjured leaves. They discussed the size

of the affected area. How it affects, how much it affects is harmful. They also discuss the increasing area of disease in Kashmir and the time when potato is mostly affected.

2.4 Scope of the Problem

The task of our model is to detect the healthy and unhealthy crops. If a crop field is attacked by early or late blight disease, our model can inform farmers immediately. To do this we had to follow some systematic way. And when following those we face some issues.

- Some data of early blight and late blight are too similar.
- Some leaves have a very little infection that can't be notified easily.
- There have many other disease that can be mixed up with our method

The Random Forest classifier gives an accuracy of 97% on image processing of potato leaves. We are also optimistic with our model.

2.5 Challenges

With our model our challenge is to achieve maximum accuracy as far as possible. As much as we can achieve it will be more helpful and beneficial. For increasing our accuracy level we need a large dataset with a quality full image. We have collected our data set from "Plant Village" which is good enough . Again they have a difficulty with the comparison of two diseases. Because our model defines both early blight and late blight. And by analyzing the fresh leaves it will define the healthy crops.

CHAPTER 3

Research Methodology

3.1 Introduction

This is an overview of our thesis and the techniques that we experienced will be in this part of this report. It gives us whole information and strategies that are utilized. It gives us point by point utilization and actualization. It will similarly test the source that we have got our information from. It will show how we intend to utilize those to classify potato leaf diseases. Instruments used in research will be discussed in this part.

3.2 Research Subject and Instrumentation

3.2.1 Research Subject

We are doing this research to see an effective method that would classify potato leaf diseases with less mistake rate and with better precision. For completing it, we chose to break down pictures and find out if the leaf is affected. Cultivating potatoes is increasing day by day in Bangladesh. Most farmers in our country are uneducated. They often face problems identifying potato diseases. It is so difficult to identify a potato leaf in empty eyes, because the symptoms of some diseases are quite the same and even they look about the same. For those cases and without proper identification, the proper treatment cannot be applied. If we will use other medicine for a selected disease it may be harmful for crops and the soil. Maybe it will reduce the soil fertility, no crops will grow properly and farmers will face a great loss. For those reasons, we have chosen this as our research topic. CNN can be utilized to construct a neural model that eliminates casual picture sources and converts them into correlations with yield marks. They have a different territory for numerous neural networks that can be arranged to adjust to the central issues required for request purposes. They should be handled before they are contrasted with traditional strategies and make methodical deliveries that give a better execution. For the ultimate goal of potato disease, we have tried a few in-depth reading structures.

3.2.2 Research Instrumentation

We have used a dataset that contained medium data, 2152 images to be exact. Those were labeled 1 to 3 which meant the disease class of the leaf. Sequential models have been used to train a machine.

3.3 Data Collect

As the Covid pandemic is going on, it is absurd to expect to go to the field actually and gather the information. Thus, an open-source informational collection has been utilized. The data set used here is a part of the Plant Village dataset, which is an open source data set. The database found contains images of around 2152 in 3 different classes. All downloaded pictures have RGB shading space naturally and are put away in a compacted JPG format.

Table 3: Table of Potato leaf disease data set with image count

Serial	Class Name	Class Index	Total Image
1	Potato Early Blight	0	1000
2	Potato Late Blight	1	1000
3	Potato Healthy	2	152

In the table 3 we can see the list of the potato disease, their index number used on the experiment

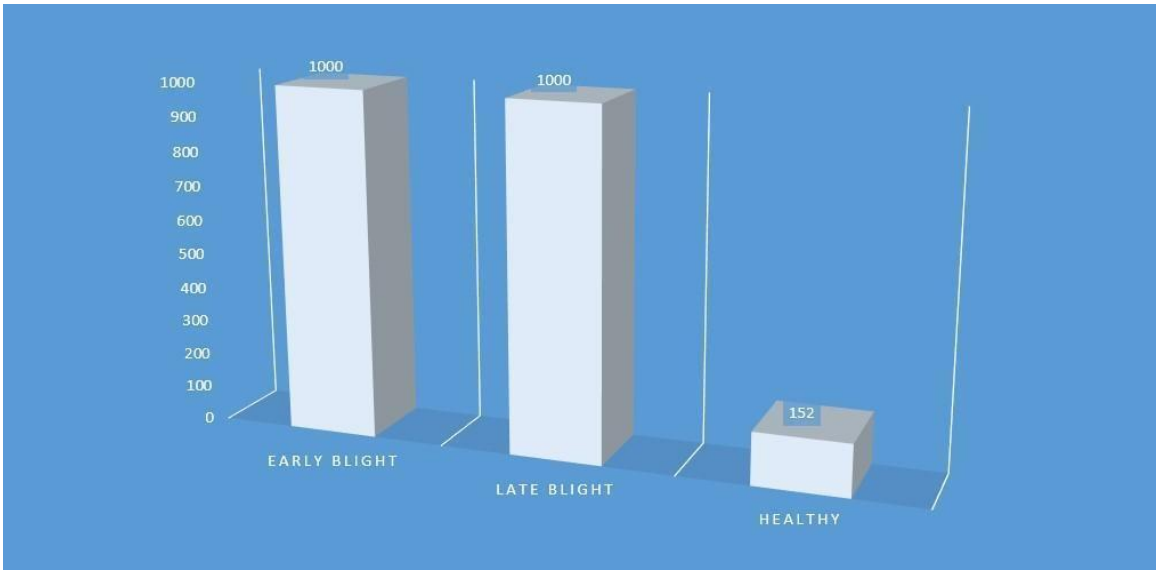


Figure 3.3.1: Class index vs total image count bar chart

Figure 3.3.2: Potato Early Blight Potato Leaf

Figure 3.3.3: Potato Late Blight Potato Leaf

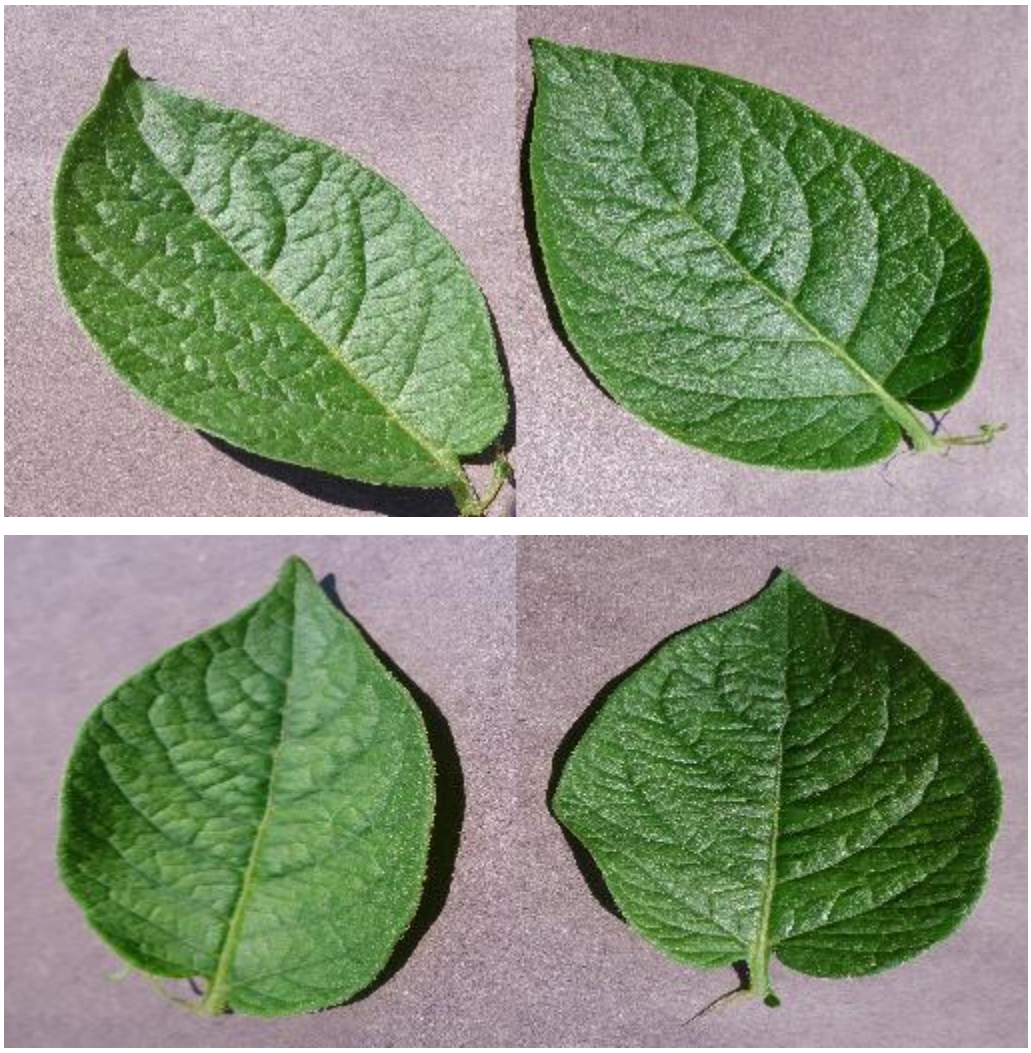


Figure 3.3.4: Potato Healthy Potato Leaf

3.4 Statistical Analysis

The images of this dataset were found with low resolutions. This is why audio output was not pre-processed. The images in the database were processed into a 60 x 60 resolution for speeding up the training cycle. The approach to measuring details or targeted objects will accelerate the training cycle. This is done by improving the mathematical status of the issue of progress. It was additionally confirmed that a couple of the perceived mistakes engaged with the introduction and end were suitable. At our proposal, we rate pictures to discover

all pixel regards with something very similar access utilizing standard implications and deviations. In terms of artificial intelligence, it is known as Z-score.

3.5 Proposed Methodology/Applied Mechanism

Computer Neural Network (CNN) can be utilized to make a PC model that eliminates casual picture sources and converts them into correlations with yield marks. They have a different region for numerous neural organizations that can be arranged to adjust to the central issues required for request purposes. They should be handled before they are contrasted with customary techniques and make methodical deliveries that give better execution. For a definitive objective of the tomato territory, We've attempted a couple top to bottom learning strategies

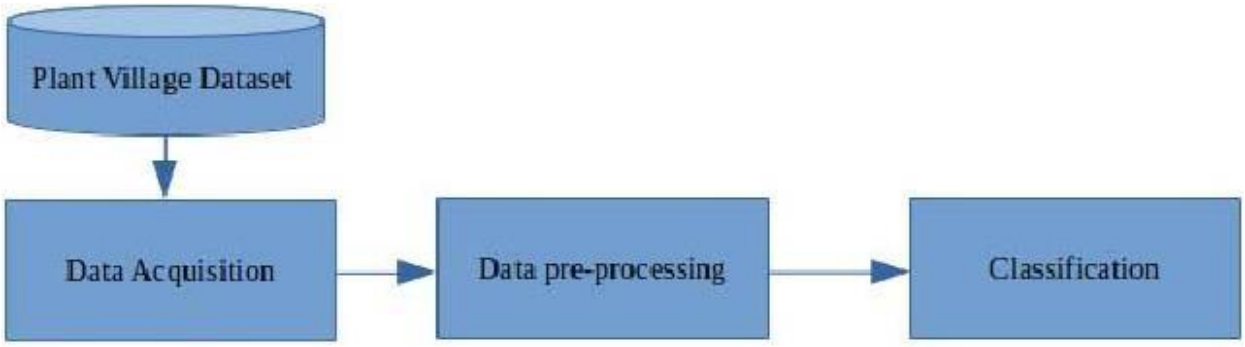


Figure 3.5.1: Proposed methodology

LeNet is a CNN-based model that includes activation, pooling, convolutional, and fully integrated layers. Structures used to classify potato leaf diseases are a variety of LeNet. It contains an additional block of layers for clarification, activation and integration unlike the original LeNet architecture.

The convolutional layer works the convolution capacity of removing highlights. With the ascend start to finish, the startling quality of the isolated components increments. The size of the channel is set to 2 x 2 although the quantity of Long Term Ecosystem Research (LTER) is expanding dramatically as we start with one square then onto the next. The top most number of LTER is 66 on the block to complete the resolutions and remains the same for others. This expansion in the quantity of terms LTERs is significant to diminish the size of the guides of items brought by the utilization of total layers across all squares. To maintain image size after the use of the convolution function, the object maps are also stacked with zero. For decreasing the size of the object maps, we use the top integration layer to speed up the preparation cycle and to model a small variation in small data changes. The size of the max-pooling piece is 2 x 2. The ReLU enactment layer is applied to all blocks in disconnected introduction. In addition, a Dropout manufacturing process has been implemented with a potential saving of 0.5 to maintain the strategic distance from crossing the train. Dropping a random act lowers the nerves in the organization while all the emphasis is on preparing to reduce model differences and simplify the organization that helps prevent overcrowding. Finally, a block comprising two structures is fully integrated into the layers of each neural organization with 500 and 10 individual nerves. The subsequent thick layer is trailed by the actuation limit of softmax to enlist expected schools for ten classes. In Figure 3.5.2 and 3.5.3 we can see the use of the model and the summary of the model.

```
model = Sequential()

model.add(Conv2D(activation ='relu', input_shape = (100,100,3), filters=64, kernel_size=(3, 3), padding="SAME", strides=(1, 1)))
model.add(MaxPool2D(pool_size=(2, 2), strides=(2, 2)))

model.add(Conv2D(activation ='relu',filters=64, kernel_size=(3, 3), padding="SAME", strides=(1,1)))
model.add(MaxPool2D(pool_size=(2, 2), strides=(2, 2)))

model.add(Conv2D(activation ='relu',filters=64, kernel_size=(3, 3), padding="SAME", strides=(1,1)))
model.add(MaxPool2D(pool_size=(2, 2), strides=(2, 2)))


model.add(Dropout(0.5))

model.add(Flatten())
model.add(Dense(512, activation='relu'))

model.add(Dense(256, activation='relu'))

model.add(Dense(units = 3, activation='softmax'))

model.summary()

optimizer = Adam  (lr=0.001)
model.compile(loss='categorical_crossentropy', optimizer = optimizer, metrics=["accuracy"])
```

Figure 3.5.2: Applying in the model

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 100, 100, 64)      1792
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 50, 50, 64)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 50, 50, 64)        36928
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 25, 25, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 25, 25, 64)        36928
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
dropout (Dropout)            (None, 12, 12, 64)        0
_________________________________________________________________
flatten (Flatten)            (None, 9216)              0
_________________________________________________________________
dense (Dense)                (None, 512)               4719104
_________________________________________________________________
dense_1 (Dense)              (None, 256)               131328
_________________________________________________________________
dense_2 (Dense)              (None, 3)                 771
=================================================================
Total params: 4,926,851
Trainable params: 4,926,851
Non-trainable params: 0
```

Figure 3.5.3:

3.6 Implementation Requirements

The details system information is given below

Hardware Requirement (minimum):

Processor:

2.4 GHz (minimum) with 4 cores CPU and also multithreading enabled.

GPU:

At Least NVIDIA GTX1050

Memory:

Minimum 8 Gigabyte Physical RAM.

Storage:

Minimum 25 Gigabyte of free space secondary memory (SSD/HDD)

Software Requirement: Operating System Linux

- Ubuntu 16.04.1 LTS or higher

Windows - Windows 10 Pro Edition V1609 or higher

Required Environments

Python v-3.6 or higher (Not more than v-3.8)

Anaconda

Jupyter Notebook WSGI

GUNICORN

NVIDIA CUDA Toolkit v-10.2

NVIDIA CUDNN Toolkit v-8.0

Packages

Pandas

Tensorflow

OpenCV

NumPy

Matplotlib

Keras

OS

JSON

Sklearn

CHAPTER 4

Experimental Results and Discussion

4.1 Introduction

Every technique or theory should be altogether tried. What could be superior to utilizing good judgment and scrutinizing it. We have in this way utilized my proposed approach as a dynamic structure [dynamic/constructive] to test our vision. This segment of the report administers the inward and outer meaning of our structure utilized. This segment further shows the establishment boundaries and the creation boundaries of the casing.

4.2 Experimental Setup

The execution of the proposed course was done on the “Plant Village” dataset. Contains images around 2152 with 3 different stages of potato leaf diseases. Keras, a neural network

application programing interface (API) written in python. We used it for model implementation.

```
train_datagen = ImageDataGenerator(
                                    rotation_range=40,
                                    width_shift_range=0.4,
                                    height_shift_range=0.4,
                                    rescale=1/255,
                                    shear_range=0.2,
                                    zoom_range=0.2,
                                    horizontal_flip=True,
                                    vertical_flip=True,
                                    fill_mode='nearest')


test_datagen = ImageDataGenerator(rotation_range=40,
                                    width_shift_range=0.4,
                                    height_shift_range=0.4,
                                    rescale=1/255,
                                    shear_range=0.2,
                                    zoom_range=0.2,
                                    horizontal_flip=True,
                                    vertical_flip=True,
                                    fill_mode='nearest')
```

Figure 4.2.1: Training & Test Data Generation

From the 2152 images, 292 images were saved for testing and 1860 images were used for training. To develop the information base, the picture upgrade procedures utilized arbitrarily 40-degree pictures, flat pivot, vertical and level turn of pictures. The enhancement is finished utilizing Adam analyzer with absolute cross-entropy as a misfortune work

```
TARGET_SIZE=100
train_generator = train_datagen.flow_from_directory(
                                                    f"{root_dir}/{'train'}",
                                                    target_size=(TARGET_SIZE,TARGET_SIZE),
                                                    batch_size=100,
                                                    color_mode='rgb',
                                                    class_mode='categorical'
                                                     )

validation_generator = test_datagen.flow_from_directory(
                                                    f"{root_dir}/{'test'}",
                                                    target_size=(100, 100),
                                                    batch_size=30,
                                                    color_mode='rgb',
                                                    class_mode='categorical'
                                                     )
```

```
Found 2032 images belonging to 3 classes.
Found 292 images belonging to 3 classes.
```

Figure 4.2.2: Training & Test Data Generation

```
learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy',
                                            patience=3,
                                            verbose=1,
                                            factor=0.5,
                                            min_lr=0.000001)
```

```
history = model.fit_generator(
                    train_generator,
                    epochs=300,
                    validation_data=validation_generator,
                    steps_per_epoch=20,
                    verbose=1,
                    callbacks=[learning_rate_reduction])
```

Figure 4.2.3: Fitting the Data to the Model

A set size of 100 has been used and the model has been trained for 300 epochs. The initial reading rate is set at 0.000001 and is reduced by a factor of 0.3 in the plain when the loss stops declining. The past suspension was utilized to screen the deficiency of approval and to suspend the preparation cycle when it heightened. All tests are performed on the AMD Ryzen 5 3600 Processor with the help of Nvidia 2060 Super GPU. In Figures 4.2.1 and 4.2.2 we can see the data processing process and in Figures 4.2.3 and 4.2.4 we can see the data modeling process and model training and the verification process.

```
20/20 [==============================] - 13s 663ms/step - loss: 0.0518 - accuracy: 0.9824 - val_loss: 0.0430 - val_accuracy: 0.9760
Epoch 59/300
20/20 [==============================] - 13s 646ms/step - loss: 0.0628 - accuracy: 0.9752 - val_loss: 0.0551 - val_accuracy: 0.9760
Epoch 60/300
20/20 [==============================] - 13s 640ms/step - loss: 0.0588 - accuracy: 0.9793 - val_loss: 0.0407 - val_accuracy: 0.9863
Epoch 61/300
20/20 [==============================] - 13s 636ms/step - loss: 0.0535 - accuracy: 0.9814 - val_loss: 0.0386 - val_accuracy: 0.9863
Epoch 62/300
20/20 [==============================] - 13s 657ms/step - loss: 0.0598 - accuracy: 0.9762 - val_loss: 0.0454 - val_accuracy: 0.9795
Epoch 63/300
20/20 [==============================] - 13s 654ms/step - loss: 0.0501 - accuracy: 0.9803 - val_loss: 0.0671 - val_accuracy: 0.9795
Epoch 64/300
20/20 [==============================] - 13s 659ms/step - loss: 0.0478 - accuracy: 0.9824 - val_loss: 0.0457 - val_accuracy: 0.9897
Epoch 65/300
20/20 [==============================] - 13s 629ms/step - loss: 0.0563 - accuracy: 0.9808 - val_loss: 0.0516 - val_accuracy: 0.9795
Epoch 66/300
20/20 [==============================] - 13s 631ms/step - loss: 0.0543 - accuracy: 0.9820 - val_loss: 0.0506 - val_accuracy: 0.9829
Epoch 67/300
20/20 [==============================] - 13s 666ms/step - loss: 0.0565 - accuracy: 0.9808 - val_loss: 0.0479 - val_accuracy: 0.9863
Epoch 68/300
20/20 [==============================] - 13s 632ms/step - loss: 0.0621 - accuracy: 0.9746 - val_loss: 0.0465 - val_accuracy: 0.9760
Epoch 69/300
20/20 [==============================] - 12s 622ms/step - loss: 0.0580 - accuracy: 0.9814 - val_loss: 0.0776 - val_accuracy: 0.9829
Epoch 70/300
20/20 [==============================] - 12s 624ms/step - loss: 0.0650 - accuracy: 0.9757 - val_loss: 0.0555 - val_accuracy: 0.9760
Epoch 71/300
20/20 [==============================] - 13s 632ms/step - loss: 0.0455 - accuracy: 0.9840 - val_loss: 0.0623 - val_accuracy: 0.9726
Epoch 72/300
20/20 [==============================] - 12s 624ms/step - loss: 0.0517 - accuracy: 0.9808 - val_loss: 0.0504 - val_accuracy: 0.9795
Epoch 73/300
20/20 [==============================] - 13s 625ms/step - loss: 0.0461 - accuracy: 0.9845 - val_loss: 0.0437 - val_accuracy: 0.9897
Epoch 74/300
```

Figure 4.2.4: On Going Model Training & Validation Process

4.3 Experimental Results & Analysis

To test the presentation of the proposed model, a wide scope of figuring measurements was utilized including exactness, misfortune, approval precision and approval misfortune. The outcomes are recorded in Table 4.3.1. They show the main gauge of the numerical measurements acquired up to the comparing epoch number.

Table 4: Machine train & test result analysis

No. of epochs	Accuracy	Loss	Validation Accuracy	Validation Loss
25	0.9736	0.0693	0.9589	0.0915
50	0.9783	0.0555	0.9760	0.0599
75	0.9798	0.0575	0.9760	0.0410
100	0.9819	0.0535	0.9863	0.0513
125	0.9808	0.0510	0.9897	0.0446
150	0.9798	0.0536	0.9726	0.0811
175	0.9819	0.0502	0.9932	0.0433
200	0.9793	0.0582	0.9795	0.0587
225	0.9798	0.0520	0.9692	0.0695
250	0.9824	0.0551	0.9760	0.0757
275	0.9798	0.0577	0.9795	0.0453
300	0.9834	0.0469	0.9795	0.0679

```
test_eval = model.evaluate(validation_generator, verbose=1)
```

```
10/10 [==============================] - 1s 89ms/step - loss: 0.0404 - accuracy: 0.9829
```

Figure 4.3.1: Model Evaluation Process

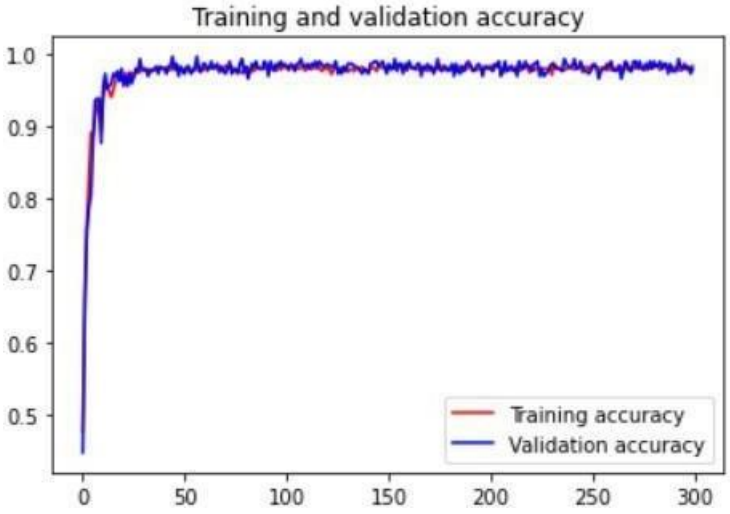


Figure 4.3.2: Training and Validation Accuracy

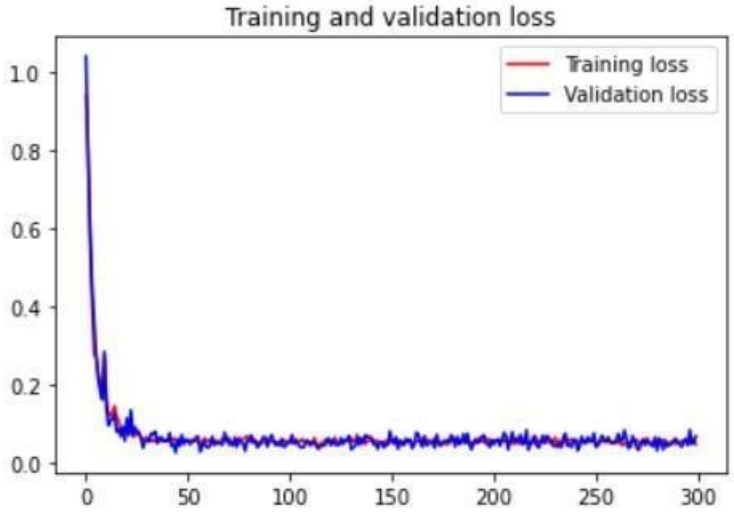


Figure 4.3.3: Training and Validation Loss

The most notable verification accuracy of 98.29% was obtained more than 300 training times, while 98.60% higher training accuracy was calculated. Normal check precision of 98.14% was obtained. This is an active part of a program developed by an in-depth learning model. Train exactness and testing locales and misfortunes against the circumstance figures

in Figure 4.3.2 and 4.3.3 give techniques to recognize and mark the rate of the model get together. y. It can be clearly seen that the model has resolved 20 epochs and the metrics do not show significant improvement over the last 10 epochs. The outcomes show that the model epoch functions admirably on data sets and can be utilized as a method for arranging 3 potato leaf diseases with insignificant source prerequisites.

4.4 Discussion

The dataset I chipped away at was extremely rich, which caused the arrangement models to accomplish better exactness. A successive model had been carried out here and 98.29% exactness which was the most.

CHAPTER 5

Impact on Society, Environment and Sustainability

5.1 Impact on Society

There are many countries in the world who have potatoes as their main meal. In Bangladesh it is taken as a side food but it's nearly a main dish for Bangladesh. There was a time in Bangladesh when the price of rice was high. And the poor people were helpless, they couldn’t buy rice because of the high rate. At that time the price of potatoes was reasonable for the helpless poor people. Then potatoes actually help them to live. They used to take potato instead of rice as it was cheap . And of course the reason for being cheap was the enough production of potatoes in those years.

Again potatoes are used to do many other things. Some alcoholic beverages are made from potatoes. We use starch from potatoes in the food industry as binder and thickener for sauces and soups. In many countries of Asia people use potatoes for making their delicious foods, they like potatoes in many ways.

we can take a look on the table below to understand the impact of potato –

Table5: comparison of vitamin content in some main food

Vitamins (mg)	Potatoes	Rice, white	Sweet potatoes	Wheat
Vitamin C	19.7	0	2.4	0
Thiamin (B1)	0.08	0.07	0.08	0.30
Riboflavin (B2)	0.03	0.05	0.06	0.12
Niacin (B3)	1.05	1.6	0.56	5.46
Pantothenic acid (B5)	0.30	1.01	0.80	0.95
Vitamin B6	0.30	0.16	0.21	0.3
Folate Total (B9) (µg)	16	8	11	38
Vitamin A (IU)	2	0	961	9
Vitamin E, alpha-tocopherol	0.01	0.11	0.26	1.01
Vitamin K1 (µg)	1.9	0.1	1.8	1.9
Beta-carotene (µg)	1	0	8,509	5
Lutein+zeaxanthin (µg)	8	0	0	220

5.2 Impact on Environment

Potatoes contain a lot of toxic compounds which are known as glycoalkaloids. The most prevalent are Solanine and Chaconine. In this. Solanine is found in other plants in the same family "Solanaceae" which includes such plants as henbane, tobacco and deadly nightshade and also the food plants tomato and eggplant. These compounds mostly protect the potato plant from its predators, and are generally concentrated in its leaves, flowers, sprouts, and fruits.

Potatoes are commonly used in research of plants. It contains parenchyma tissue which is the low metabolic activity of potato and the cloning nature of the plant and it also provides a pure "model tissue" which can be used for experimentation. Wound-response studies are commonly experimented on potato tuber tissue, as followed by electron transport experiments. To do this, the tissue of potato tubers have similarity with Escherichia coli Caenorhabditis elegans and Drosophila melanogaster, they all are known as "standard" research organisms.

Chapter 6

Summary, Conclusion, Recommendation and Implication for Future Research

6.1 Summary of the Study

After the whole study we decided that it's very important for people to produce enough goods. Because man can't live without eating and also we have to take a proper diet for a healthy life for which good food is necessary. Here, potatoes are a bunch of good nutrition. And can give a lot of energy. So people have a huge demand for potatoes. It is also used to make many dry foods that can be preserved for a long time. And children like it very much. So more potato production of potatoes can make a more effective change in our food habits.

6.2 Conclusions

Early detection of these diseases can allow us to take necessary steps to mitigate economic and measures and production losses. CNN is our way to get rid of the diseases. Our target is to detect the diseases as early as possible so it can't be spread. In our everyday life we need a lot of energy and these crops are a source of a lot of energy. When we will be able to do so, the production will grow and farmers can achieve their target. All over Asia potatoes are very dependent. This demand for potatoes will not decrease in any way so the best solution is to produce more.

6.3 Implication for Further Study

As far as we know, we are still stuck at detecting some diseases. but for more progress in our agriculture we need to do some more further work. Such as-

- Detecting more diseases
- Analyzing roots as well as leaves
- Improving our accuracy rate.
- Providing the way of cure for the diseases to the user.
- Giving the proper instruction to the users.
- Analyzing weather that is friendly.

Appendix

CNN: (Convolutional Neural Network) It's one of the classes of deep neural networks which have the application to analyze overt images. It is also known as space invariant or shift invariant ANN (artificial neural networks).

GPU: (Graphics Processing Unit) GPU is an extraordinary electronic circuit which is generated to alter memory and manipulate rapidly to accelerate the images creation to a display device in a frame buffer longed for output.

WSGI GUNICORN: GUnicorn (Green Unicorn) is a WSGI HTTP Server in Python for UNIX. GUnicorn is a pre-fork worker model and Ruby's Unicorn project is the system from where it is taken

NVIDIA CUDA: That's a special Toolkit which provides a development environment to create high performance GPU-accelerated applications. A C/C++ compiler, GPU- accelerated libraries, a runtime library, and debugging and optimization tools are included in the toolkit to build and deploy an application on major architectures including Arm, x86 and POWER.

NVIDIA CUDNN: This is a Deep Neural Network library (CuDNN) which is a GPU-accelerated library of primitives for knowing about deep neural networks. For implementations and standard routines such as forward and backward convolution, pooling, activation layers and normalization, CuDNN is highly recommended.

TensorFlow: TensorFlow Federated is an OSS framework for machine learning on decentralized data. TFF provides federated learning algorithms to run on decentralized datasets. It contains a flexible, comprehensive ecosystem of community resources, libraries and tools.

OpenCV: (Open Source Computer Vision Library) It's a programming functions library that mainly focuses on real-time computer vision. This is a cross-platform library and free to use under the open-source Apache 2 License.

NumPy: NumPy based on Numerical python and it is used like a Python library. Actually it works with arrays. It also works with matrices, algebra etc. If we want to do data science work with Python, 'NumPy' is a very early package.

Matplotlib: Its visualization is very important for better understanding of any data. In the case of machine learning or deep learning, it is a very complex and flawed task to come to a conclusion from any raw data. Using the Matplotlib library in Python, it is easy to draw data visualizations or graphs / plots.

Keras: Keras is developed by Google. It is a high level deep learning API. It is like human beings and it implements neural networks. If we use Keras, we don't need many users. It shows clear error messages.

OS: OS means Operating System. It is a computer program. It works to coordinate the computer's hardware and software according to the user's instructions. It works for input, output, storage and processing of various computer programs.

JSON: (JavaScript Object Notation) It is structure based, schema less, data text based, order lists and presentation based on key-value pairs. JSON is derived from JavaScript but it is very important in most major programming languages via native or library. It is very common, but not too exclusive. To exchange information between web clients and web servers JSON is commonly used.

API: API means Application Program Interface. Through API one program can share some data with another program. There are so many devices like Android, iPhone, PC etc. They work quite similar. If they work the same thing, we don't need different languages, that time we just need a brain, it's called API

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