TRANSFER LEARNING APPROACH FOR PLANT LEAF DISEASE DETECTION USING CNN WITH PRE TRAINED FEATURE EXTRACTION METHOD MobilNetv2

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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 "**Transfer learning approach for plant leaf disease detection using CNN with pre trained feature extraction method MobilNetv2**", submitted by **Raida Moyazzoma**, **ID No: 173-15-10267, Md. Al Amin Hossain**, **ID No: 173-15-10348,** and **Md. Hasanuzzaman Anuz**, **ID No: 173-15-10298** 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 (BSc) and approved as to its style and contents. The presentation has been held on 7th October 2020.

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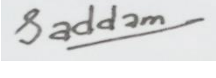

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We hereby declare that this thesis has been done by us under the supervision of **Mr. Abdus Sattar, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has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

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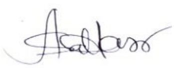

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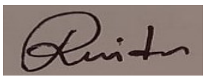

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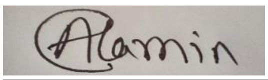

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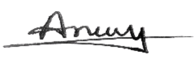

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ABSTRACT

Economy of Bangladesh mostly depended on agriculture. As a small country our population is over than the limit. We are a developing country. For national GDP growth must be to increase the production. Every year a huge amount of agricultural production losses for the crop disease. As we know, most of the farmers in our country are illiterate, have no proper knowledge about the disease, that’s why they cannot manually detect the disease. I think if you properly detect the disease at the early stage we can solve the issue. We develop a model that can classify leaf disease. We focus on 5 major production crops in Bangladesh. Using computer vision technique our farmer will get the benefit. We use convolutional neural networks for classifying images. An algorithm cannot properly capture the features of existing data that’s why we use pre-trained feature extraction method that is MobileNetv2. MobileNetv2 is very useful for mobile devices. The research contains the proportions of validation accuracy of 90.38%. This approach resulted in the agriculture sector that will help a farmer to classify disease from harvest. The main goal of our model is minimize the damage of suffering plants that can help to growth of production. By solving this issue themselves farmers can also reduce cost. Our goal is that they can cure their crop at the right time. To achieve this goal we tend to think that we should develop a way to detect the leaf disease. We collect several kinds of leaf. And then any leave can be tasted by our model. By using our model we try to reduce the leaf disease.

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INTRODUCTION

1.1 Introduction

Bangladesh is one of the developing countries where the majority of the population of the country is dependent on agriculture and agriculture production. Agriculture sector is the backbone of our economy. And its economy has traditionally been based on agriculture. Day by day our social and economic are changed by the agriculture sector. Around 60% land is used for agricultural production. Now in our country two people work in the agriculture field from five people. Almost 15% GDP comes from this sector. Nowadays the area of land decreases for many reasons like houses, roads, and development projects. Agriculture is not only to feed an even growing population but it's also an important source of energy. Nowadays studies show that plant leaf diseases affect both quality and quantity of plants in agriculture production. In Bangladesh leaf diseases are an important cause for reduction of agronomics. Farmers face many problems for controlling the diseases on plants. Farmers are not able to explain diseases properly on call and need to analyze the image affected area of disease. Other hand, the naked eye observation of experts is the main approach adopted for detection and identification of plant diseases. But the naked eye observation is time consuming, expensive and takes a lot of efforts. In this manner, identifying and recognizing an infection at an early arrangement is a critical assignment for farmers. So detecting the diseases is the important part in the agriculture field and these involve judicious diagnosis and appropriate supervision to control the massive losses.

Nowadays in our country the major problem of our plants is increasing leaf diseases highly because of air pollution, soil pollution, increasing temperature, insects and bacteria. Most of our farmers are not educated, most of them are illiterate that's why they can't properly classify diseases. Although 43 % people work in agriculture but this field does not develop as government expected outcomes. A bacterial effected leaf disease is the prime reason. Farmers are not familiar with these kinds of diseases and even they do not know how they can solve it. We focus on how a farmer can detect the disease at an early stage and classify it properly. If we can detect disease at the primary stage it will help to growth of the production. As we know, in our country researchers discover new medicine continuously but lack of disease detect farmers cannot solve it properly. Our main goal in this research is that as we can detect the leaf disease and classify it properly, we work on major crops in Bangladesh. Our model is able to detect diseases from different angular pictures. We expect our model will work properly on any kind of leaf diseases, if anyone would like to add more data or images.

1.2 Motivation

The economy of Bangladesh mostly depended on agriculture but still we are not able to produce enough crops as our population demands. Most farmers did not know about crop disease when disease attacks on the leaf they decide to scatter chemicals. That is very harmful for the human body. It is necessary to produce disease free crops. The economy of a country depends on their people. If people are healthy then they can contribute to the growth of the economy. So we are going to help the farmer learn how they can quickly analyze disease of their crop. Hope that this will help our farmers to produce more crops and economic growth also.

1.3 Problem Definition

We try to make a model for which plants are affected by various types of tissue disease from several angle images. The main goal of our model is minimize the damage of suffering plants that can help to growth of production. Our model will work on different kinds of bacterial leaf disease for the major crops in Bangladesh. We choose image classification techniques using CNN Deep Learning Architecture to solve this issue.

1.4 Research Questions

Here are the main questions those are focuses in this thesis are given below:

- Why need image classification?
- How do we determine which learning method is appropriate for image classification?
- What are the characteristics of different image classification methods?
- Why is image classification with CNN better than others?
- What is the role of deep learning in image classification?

1.5 Research Methodology

At this stage we explain data collection, data categorize, data augmentation, data pre-processing, train and validation, model evaluation, classification and output.

1.6 Research Objectives

Leaf disease detection is beneficial for our farmers. There are some objectives of our research.

- Early stage disease detection
- Classify disease
- Production growth
- Self-dependent
- Increasing annual income

1.7 Research Goal

Our goal is leaf disease detection using image classification technique. Most of the farmers in our country are under crisis. Farmers are facing a problem with their crop disease; they cannot detect it at primary stage. Most of the farmers in our country are illiterate so it is not easy for them to identify the disease to their crop. So, that time they could know the disease in the plant. Our goal is that they can cure their crop at the right time. To achieve this goal we tend to think that we should develop a way to detect the leaf disease. We collect several kinds of leaf. And then any leave can be tasted by our model. By using our model we try to reduce the leaf disease. Here we use CNN with MobileNetv2 feature extractor.

1.10 Research Gap

Most of the work done for one specific leaf disease. Their class is limited. They did not use feature extraction methods that’s why model complexity and computation raise. We develop this model for Bangladesh perspective for major crops that were being produced. Using MobileNetv2 our model complexity is reduced. We work on 21 classes from five crops.

1.11 Research Layout

Chapter 1: will describe our project introduction, motivation, Problem Definition, Research Question, Research Methodology, Research Objective, Research Goal, Research Gap and the expected results.

Chapter 2: will discuss the background of this research and the related work and current status based on Bangladesh perspective..

Chapter 3: will describe the situation of computer vision in the field of agriculture in Bangladesh.

Chapter 4: will discuss the implementation process of the model

Chapter 5: will describe the result and analyze it.

Chapter 6: will describe the conclusion and future scope.

Chapter 7: related references will be shown in this section.

CHAPTER 2

BACKGROUND

2.1 Introduction

In the 21st century, image plays a vital role for modern technology, life, medical, business, education and, etc. It is useful for almost every area. For the information sharing images are the primary source. An image is more than thousands of lines. Day by day our technology is growing, and our machine is getting intelligence followed by the human brain. A computer can interpret images easily. By processing an image machine can perform its tasks automatically. Many of the technologies are used for such kinds of tasks. Convolutional neural networks are among one of them useful for image classification.

2.2 Related Works

Convolution Neural Network (CNN) is one of the best image classification technologies. CNNs work well with images (data) that create a spatial relationship. CNNs are a go-to strategy for any sort of expectation problem including picture information as an input. Image processing using CNN, for leaf diseases detection is powerful for recognizing the image. Many researchers are trying leaf disease detection using image processing and different algorithms where a few researchers got success in this type of work.

Ghaiwat et al. [1] presents a thought on a different course of action methodologies that can be utilized for plant leaf disease order. For the given test model, the k-closest neighbor strategy is by all accounts appropriate just as easiest of all calculations for class prediction. In the event that preparation information isn't directly distinct, at that point it is hard to decide ideal boundaries in SVM, which shows up as one of its downsides.

Suhaili Kutty et al. [2] proposed the method to classify Anthracnose and Downey Buildup, watermelon leaf diseases. This region of intrigued has to be recognized from an infected leaf test based on the RGB color component. At that point to diminish commotion and for division the middle channel is utilized. What's more, for order neural organization design acknowledgment tool compartment is utilized. The proposed strategy accomplished 75.9% of exactness based on its RGB cruel color component.

Wan Mohd Fadzil et al. [3], talked about an infection detection method for orchid plants that clears out. The orchid plant leaflet pictures have gotten the utilization of a computerized camera. The calculation makes use of a total of different techniques comprehensive of border segmentation strategy, morphological preparing and filtering technique utilized for categorizing input pictures into two disease classes as dark leaf spot and sun-powered sear.

P.Revathi et al. [4] in this paper comprises two stages to recognize the influential aspect of the ailment. At first Edge location based Image division is done, lastly picture investigation and characterization of ailments is performed utilizing our proposed Homogeneous Pixel Counting Technique for Cotton Diseases Detection (HPCCDD) Algorithm. The target of this exploration work is to recognize the ailment affected portion of cotton leaf don by utilizing the picture examination procedure.. This work discover the PC frameworks which examine the info pictures utilizing the RGB pixel tallying values highlights utilized and distinguish malady astute and next utilizing homogenization procedures Sobel and Canny utilizing edge identification to distinguish the influenced pieces of the leaf spot to perceive the sicknesses limit is white lighting and the outcome is acknowledgment of the infections as output.

Mrunalini et al. [5] present the procedure to characterize and recognize the distinctive infection through which plants are influenced. The Bangladeshi Economy, a Machine learning-based acknowledgment framework will end up being exceptionally helpful as it spares efforts, money and time as well. The methodology given in this for highlight set extraction is the shading co-event technique. For programmed recognition of infections in leaves, neural organizations are used. The approach proposed can fundamentally uphold a precise identification of leaf, and is by all accounts significant methodology, if there should be an occurrence of steam, and root ailments, investing fewer amounts of energy in the calculation.

J. S. Smith and A.Camargo [6], proposed a procedure for perceiving the optical signs of plant leaf diseases by using the picture preparing strategy. The exactness of the algorithm is tried by coordinating the pictures, which were physically with those naturally fragmented.

Usama Mokhtar et al. [7] portrayed the strategy of Tomato leaves maladies identification and illnesses are: Powdery buildup and early curse. Picture preprocessing included different procedures, for example, perfection, eliminate clamor, picture resizing, picture segregation and foundation eliminating for picture upgrade. Gabor wavelet change is applied to include extraction for highlight vectors additionally in order. Cauchy Kernel, Laplacian Kernel and Invmult Kernel are applied in SVM for yield choice and preparing for malady recognizable proof.

Dheeb Al Bashish et al. [8], analyzed the technique to identify the plant leaf infection that exists on leaflet and stick. The introduced framework is together of the K-Means division technique and neural organization utilized for grouping of portioned images. Classification exhibited normal accuracy of 93%.

The objective of Sanjeev Sannaki et al. [9] is to analyze the infection utilizing picture handling and artificial intelligence techniques on pictures of the grape plant leaf. They classify primarily two infections, wool buildup and fine buildup of the grape leaf. Covering is utilized to eliminate the foundation to improve precision. For safeguarding data of the influenced segment of leaf, Anisotropic Diffusion is utilized. Division is done utilizing the k-means grouping strategy. After division, inclusion happens by ascertaining Gray Level Co-event Matrix. Lastly, classification is finished utilizing Feed Forward Back Propagation Network classifier. They have utilized just Hue highlights which gives more exact outcomes.

Zhen Ma et al. [10] make an audit on the current division calculations utilized for medical pictures. Algorithms chiefly classify in three classifications as per their primary ideas: the main dependent on edge, the second dependent on pattern recognition techniques and third one dependent on deformable models. In ongoing years the third classification of calculations are focused on deformable models because of escalated examination. A portion of the fundamental utilization of these calculations is dividing organs and tissues in the pelvic depression area. These are examined through a few primer investigations.

Sachin Khirade and A. B. Patil. [11], examined the primary strides of picture handling to recognize inflection in plants and classify them. It includes steps like picture procurement, picture preprocessing, picture division, highlight extraction and classification. For division, techniques like otsu's strategy, changing over RGB picture into HIS model and k-means grouping are there. Among all, k-means grouping strategy gives exact results. After that, extraction is carried out like color, surface, morphology, edges, etc. Among this, morphology including extraction gives better results. After component extraction, classification is finished utilizing strategies techniques like Artificial Neural Network and Back Propagation Neural Network.

Vijay Jumb et al. [12], talked about a procedure of division exploitation Otsu's thresholding and K-means clustering. The main pictures range units recover to HSV color space and so the V part is utilized for multi-thresholding. The extended work contrasts this division strategy and various procedures like fluffy C-means, area developing, etc. These procedures square measure compared utilizing two measurements for example top flag to size connection (PSNR) and mean sq. error (MSE).

Bhog and Pawar [13] have joined the concept of neural network for the classification of cotton leaf infection analysis. For division, K-means clustering has been utilized. Diverse cotton leaf infections are like Red spot, white spot,Yellow spot, Alternaria and Cercospora on the Leaf. For experimentation, the MATLAB tool kit has been used. The acknowledgment accuracy for K-Mean Clustering technique utilizing Euclidean separate is 89.56% and the execution time for K-Means Clustering technique utilizing Euclidean separate is 436.95 second.

Rong Zhou et al. [14], clarified technique for versatile and progress distinguishing leaflet fix in sugar beet. For capturing pictures, a Nikon photographic camera was utilized that was mounted on a stand to remain steady separation. The creator utilized white authors though capturing pictures to stay away from the extra intricacies in measure. The technique executes cross breed strategies for direct coordinating and backing vector machines. This technique utilization color basically frames choices for division, direction code coordinating and support vector machine (SVM) classifier for last disease characterization.

Chaudhary Piyush et al. [15] in this paper, authors depict a calculation for malady spot division in plant leaf utilizing picture preparing methods. This paper also describes a cycle of malady spot identification that is finished by contrasting the impact of HSI, CIELAB, and YCbCr color space. For Image mitigating Median channel is utilized. In the last step, by applying Otsu technique on color components, computation of limits should be possible to discover the infection spot. There is some clamor due to foundation which is appeared in the exploratory outcome, camera glimmer and vein. The CIELAB color model is utilized to eliminate that noise.

Saradhambal.G et al. [16] proposed crop development assuming a basic part in the horticultural field. Directly, the loss of food is mostly because of contaminated yields, which reflexively lessens the creation rate. To recognize the plant sicknesses at an inopportune stage isn't yet investigated. The primary test is to decrease the utilization of pesticides in the rural field and to increment the quality and amount of the creation rate. Our paper is utilized to investigate the leaf infection expectation at an inopportune activity. We propose an improved k-mean grouping calculation to foresee the tainted region of the leaves. A color-based division model is characterized to fragment the tainted district and set it to its applicable classes. Exploratory investigations were done on test pictures as far as time intricacy and the territory of the tainted district. Plant maladies can be recognized by picture preparing procedure. Ailment location includes steps like picture procurement, picture pre-handling, picture division, highlight extraction and grouping. Our task is utilized to identify the plant infections and give answers for recuperating from the malady. It shows the influence aspect of the leaf in rate. We intended to plan our project with a voice route framework, so an individual with lesser skill in programming ought to also have the option to utilize it without any problem.

Pawanp.warne et.al. [17], depicts the approach to prevent the crops from hefty misfortune via cautious identification of disease. In cotton, inflections in leaves are a basic issue since it decreases the creation of cotton. The locale of interest is leaf since most infections happen in leaf only. The inflections that happen in cotton leaves are Alternaria, Cercospora and Red Leaf Spot.Histogram balance is used to preprocess the information picture to expand the contrast in low difference picture, K-means bunching algorithm which classifies objects. Division is based on a lot of highlights that segment the preprocessed picture into a number of classes. Lastly grouping is performed utilizing Neural-network. Infections in cotton leaves are identified accurately utilizing picture processing techniques. It is utilized to break down the cotton inflection which will be helpful to farmers.

Above all the research paper gives us valuable knowledge to support our research paper. Here all research papers present different methods for plant leaf disease detection image processing technique. There are many processes in computerized or computer vision for leaf malady detection and classification. But still there is a lack in research topics because all the disease cannot be identified using a single method. The main goal of this paper is to detect all kinds of leaf disease identification and classification using a single method. For this, farmers can easily gather better information about leaf disease.

2.3 Bangladesh Perspective

Our goal is leaf disease detection using image classification technique. Most of the farmers in our country are under crisis. Farmers are facing a problem with their crop disease; they cannot detect it at primary stage. Most of the farmers in our country are illiterate so it is not easy for them to identify the disease to their crop. So, that time they could know the disease in the plant. Our goal is that they can cure their crop at the right time. To achieve this goal we tend to think that we should develop a way to detect the leaf disease. We collect several kinds of leaf. And then any leave can be tasted by our model. By using our model we try to reduce the leaf disease. Here we use CNN with MobileNetv2 feature extractor.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

By using CNN with MobileNetv2 we achieve 90.38 % accuracy where the number of classes are 21 from five crops (bean, tomato, potato, corn and pepper).

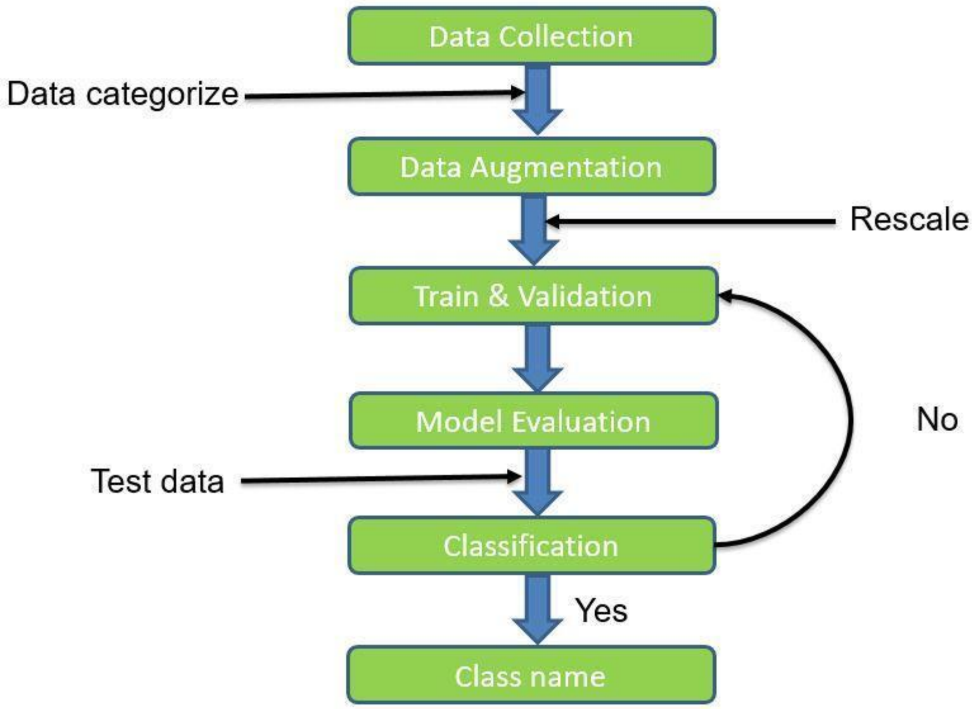

Figure 3.1.1 Steps of Data Collecting and Processing

3.2 Experiment Data Set

We collect data by capturing images on our cell phone from the plants field. Our dataset contains 7800 images where train data contains 4976 images, test data contains 1102 images and validation data contains 1742 images. We collect data from five crops with 21 classes. For each class train contains 200 images, validation contains 100 images and test contains 50 images. Some classes of images are given below:-

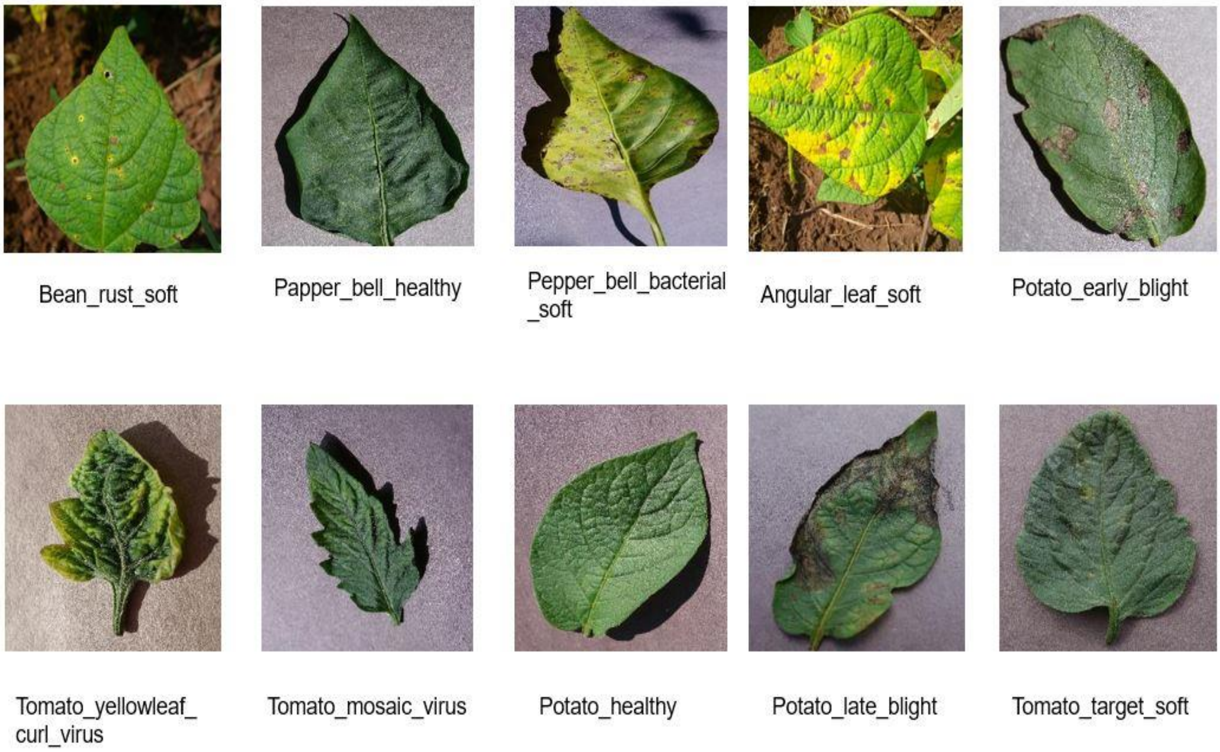

Figure 3.2.1 Collected Dataset

3.3 Model Architecture

As we know CNN mostly used algorithms on image related work like computer vision. For the internal structure of CNN and its working procedure very familiar with image. When we use deep learning with any feature extractor method it works as transfer learning.

3.3.1 Introduction to Deep learning

Deep learning is a technique that can learn and improve by itself. Basically, deep learning design on human brain visual cortex architecture, how the brain's neurons work. It can extract features from data, which features are important for describing a contained problem. When our data set is very large and the problem is more complex machine learning fails to solve this type of problem where DL can give us good performance. For image classification, deep learning follows two steps: first it extracts the feature of the image and then it classifies. The learning ability of deep learning is most powerful which improves classification accuracy.

In this digital world, images are used in various fields. Images can be in various form black and white level images, no grey scale images, RGB images, hue saturation value, binary images, and etc. Every image can contain a huge amount of features but all features are not necessary for classification.

3.3.2 Artificial Neural Network (ANN)

Artificial neural network model is a computation network. Its structure and functionality is followed by the human brain. Its working principle follows the biological neuron. Biological neurons consist of three parts dendrites, axon and synapse.

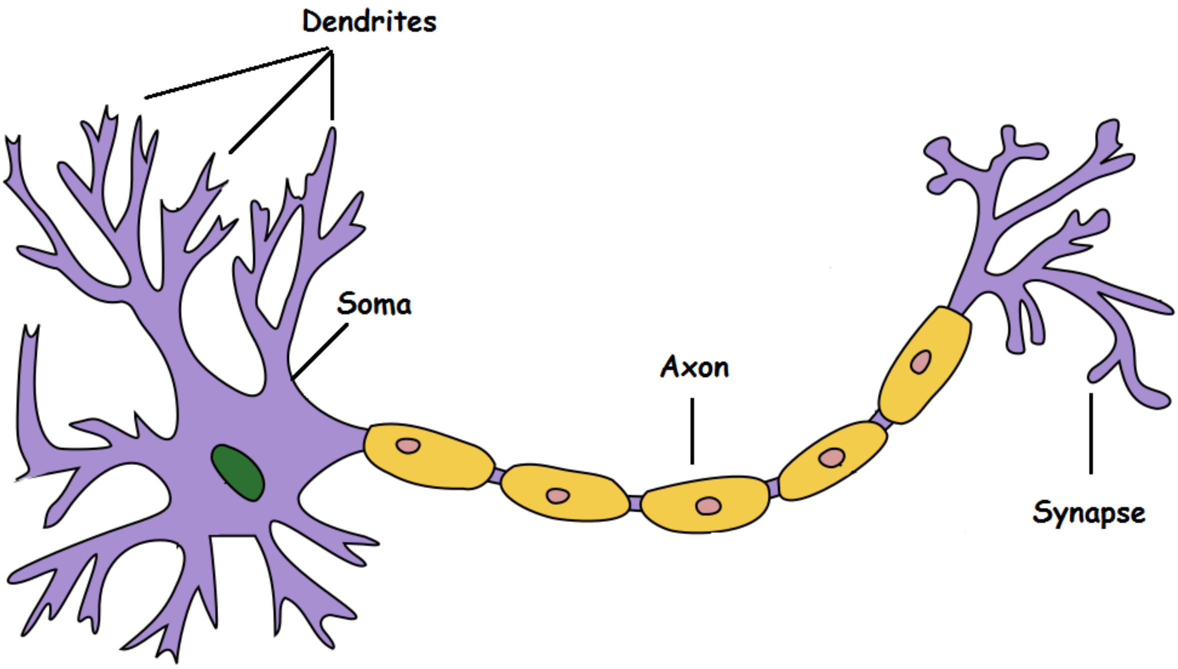

Figure-3.3.2.1: Biological Neuron [21]

Dendrite is an input module, which gets signals from other neurons and they input the cell body which is the operational center of the neuron. Basically the cell body does some kind of computation of this signal which is an electric signal it modulates and then passes on along the axon to all of the different synaptic terminals. Which are connected to other neurons. Through synaptic and though axon neurons connect other neurons.

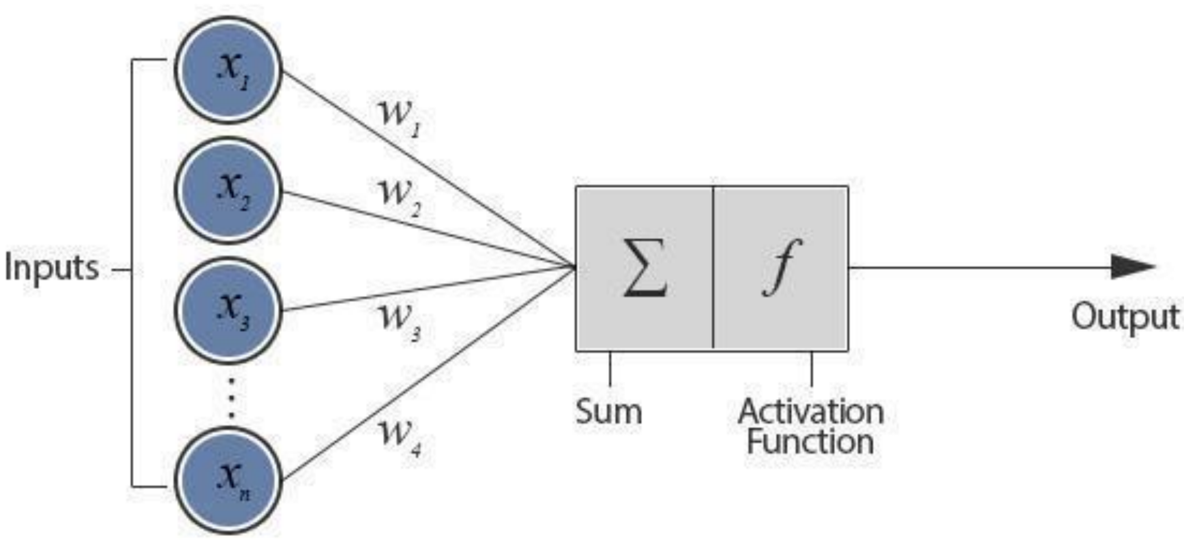

Figure-3.3.2.2: Artificial Neuron [22]

Similar to the human brain, ANN is interconnected by its neurons and is called nodes. Every neuron connects with each other by edges. The first layer is an input layer that contains raw data like image, text, sound and, etc. Every node sends information to next layer nodes that are connected by edges. Edges contain a weight that can change depending on experience. In the neuron cell body has two functions one is sum and another is activation. Sum triggers the activation function if activation is satisfied then it will go to the next layer nodes as input.

3.3.3 Feature Selection

For model performance impact of feature selection is a great deal. We do not every feature of a data, some feature impact negative and some feature impact partially positive in a model. Basically feature selection removes noisy and redundant features. Effective Feature selection increases model accuracy.

3.3.4 Image classification using machine learning

Classifying an image is easy for humans but it is a difficult task for a machine. It is a most important and interesting problem in the area of computer vision. In Image classification you show a picture and the model will tell you the belonging class. In computer vision image classification can reduce object detection and segmentation problems. There are a huge number of jobs we can do by image classification. For example Automated Image Organization – from Cloud Apps to Telecoms, Stock Photography and Video Websites, Boosting Driverless Car Technology, Optimizing Medical Imagery, Improving Augmented Reality Gaming and Applications and, etc. Basically image classification has two methods one is pixel based and another one is object based. Where pixel based classification contains spectral information and object based classification based on spectral and spatial information. In pixel based classification one pixel cannot use another pixel's information but an object based method can do it. One important thing is that “object” just refers to contiguous regions of pixels and not whether or not there is a target object within that region of pixels.

3.3.5 Need of Image Classification

In recent progress image classification can help processing and categorizing an object. Now in our modern technology we have billions of websites and the most important aspect for a website is image. This is the first massage for your product and your customer. Suppose a large organization contains a huge amount of data with visuals that cannot manually manageable. It is difficult to categorize when metadata of images is not available for the visual database. With the help of image classification it is easy to classify the large amount of visual database automatically. Some important cases where image classification is really helpful.

- Automobile Industry: self-driving car, manufacturing automobile industry is this technology used to reduce road accidents and drivers can follow the traffic rules.
- Gaming: for find out real location
- Healthcare: microsurgical procedures, emotion detection
- Merge reality: AR, VR
- Retail industry: the quality and price of a product
- Security industry: drones, security cameras, facial recognition biometric devices

3.3.6 Why image Classification with CNN is better

In CNN when we go to the next layer the number of parameters will increase greatly. For this reason our model complexity will increase and computation tasks will be harder. Tuning a large number of parameters CNN can diminish the time. CNN can reduce the number of parameters in an effective way without down the model quality. By sliding windows we can reduce the dimensionality. The main reason is the feature selection method. CNN can automatically extract the feature from an image. It can cover local and global features. Finally CNN has transfer learning so it can learn more with less error.

3.3.7 Convolutional Neural Network based image classification

In deep learning, CNN was built on the principle of human brain architecture. CNN consists of special nodes that are called neurons. Neurons are placed as a stack into different layers. Each neuron of every layer connects together with the next layer. It works as a fed forward network, where data goes right from input to output layer. In every node, perform a mathematical operation called dot product and send it to the ever connected node of the next layer. The dot product basically operates between input and weight of corresponding edges. CNN follows some rules of the visual cortex. Most popular technique is image classification. When we want to see a certain region of an object not only we see this certain region but also we see the whole object but our focus is a particular portion of this object, like if we want to see a wall our focus will be a certain region but we can see the whole wall at a time. This certain region of this called the convolution. We see a picture but our computer cannot see it, the computer can see a matrix of image. Suppose a picture with 224*224 the array will be 224*224*3 where image width is 224 pixel, height is 224 pixel and 3 is the RGB channel value. The RGB value range is 0 to 255 and it describes the density of each pixel. Our network is a fed forward network the image passes through the convolution, pooling and fully connected layer. First we go for the convolutional layer, the images are entered as an input. It reads the image matrix from the top left corner and makes a smaller matrix its called filter and then the filter makes a convolution. Filter multiply the original value to its value and sum it. When the filter reads the top left corner image then its go 1 unit right. When all the matrices are filtered we can get a new matrix that is smaller than the input matrix. After that the pooling layer reduces the dimension of the image. There are different types of pooling max pooling is best among them. If the maxpool=(2,2) then first it select a 2*2 matrix after that it chooses the biggest value from it for the new matrix. Fully connected layers take information from the convolution layer. Fully connected layers contain a vector for every class.

3.3.8 Role of Deep Learning in image classification

Similarly others machine learning algorithms DL take the training data and train by it after training to make a decision for new data. But deep learning can with neural networks make a decision on its own for unlabeled data. This method is very useful for leaf classification between a healthy leaf and a disease leaf. In neural network output of one algorithm is output of another algorithm and which present network side by side. This methodology makes a system that can generate a decision like a human. For human behavior or thinking like a human the system getting artificially intelligent.

3.3.9 CNN (Convolutional Neural Network)

CNN is most popular for images data. Every image contains 3 dimensions: first height, second weight and third one is RGB value or number of channels. Height and weight tells us the image resolution and RGB value tells us the red green blue intensity of an image. Neural networks reduce the image dimension and processing time to remove under fitting problems. If our input image dimension is 244*224*3 our input vector will be 150528 and it is one dimension. This input vector is too large to feed.

Layers of CNN are:

· Convolution layer

· Activation layer (e.g. using ReLu)

· Pooling layer

· Batch norm Layer

· Dropout Layer

· Fully connected Layer

3.3.9.1 Convolution Layer:

The main layer of CNN is convolution layer. Convolution merge sets mathematical operation. We use a convolution filter to make a feature map.

Image Matrix

1	0	0	1	1
1	0	1	1	1
0	1	1	0	1
0	1	0	1	0
1	1	1	0	1

Filter Matrix

1	0	0
1	0	0
0	1	1

Figure-3.3.9.1.1: Image matrix multiplies kernel [23]

On the left side input a convolutional layer. On the right side is the kernel of the convolutional layer. In our figure we can see a 3*3 convolution. By sliding the filter we compute the convolution. Every location we do element wise matrix multiplication and sum the result. After getting the sum we put it into a feature map the green are where we calculate our mathematical operation is called receptive area.

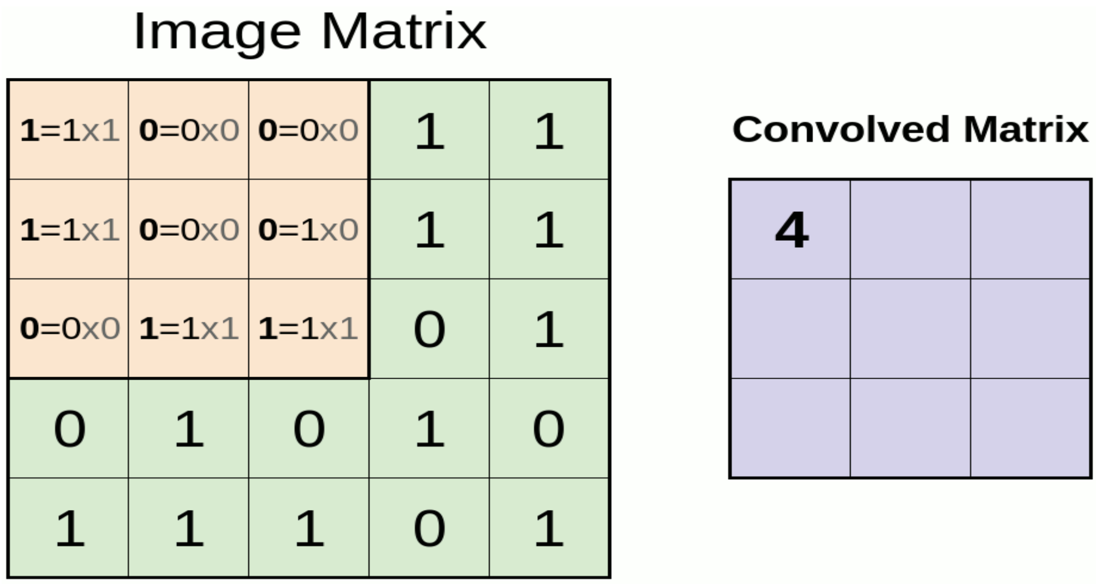

Figure-3.3.9.1.2: 3*3 output matrix [23]

Here we select the top left matrix that's why our sum will be put into the top left position of the feature map matrix. If our receptive area shifts right for one step the sum of this area will be put on the right side of the previous element of the feature map. This process goes on continuously to the last receptive area. We see an example where the operation dimension is 2d and it is a 3*3 filter. But in reality the dimension is used in 3d.

3.3.9.1.1 Parameters which helps in adjusting CNN's performance:

- Stride: Stride defines how much we move after every step. If the value of stride is 1 then the receptive field will move one column for every step. For less overlapping we can use big stride values. If we use bigger stride values than our feature map dimension will reduce.
- Padding: padding is used to make a bigger feature map if we want the same dimension as input. We can use padding surround the input with the value zero.

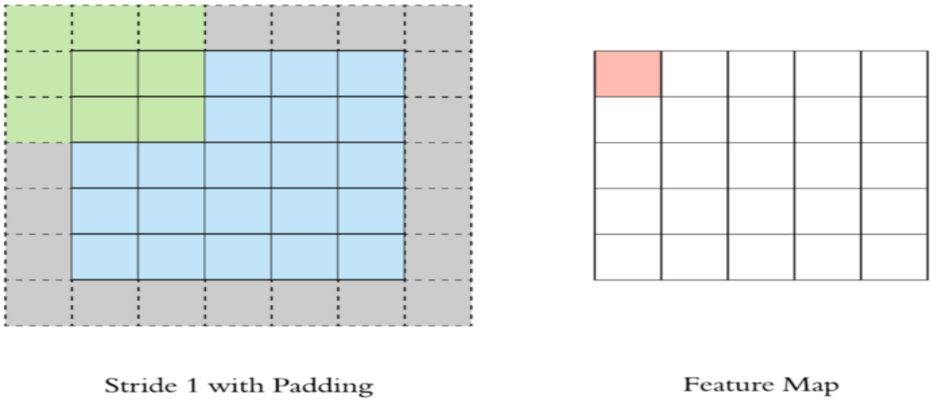

Figure-3.3.9.1.1.1: Stride padding [24]

The gray area is padding. Basically padding is used to preserve the size of a feature map.

- Filter: Filter is an input of a convolution. It is also called kernel. Kernel is used to multiply with the input matrix to get a feature map.

3.3.9.1.2 Dimension reduction in CNN

If input matrix is 5*5 dimension and we use 3*3 dimension filter convolution will produce 3*3 feature map. In pooling if we set maxpool argument is 2, 2 it produce a single vector against the 2*2 matrix.

3.3.9.2 Pooling Layer

After convolution pooling is being performed. Pooling layer is used to reduce the dimensionality which can decrease the training time and over fitting. There are several types of pooling MaxPooling is most popular among them that take the max value from a window. Basically pooling does not contain any parameters. But here we define the window size and stride as like convolution.

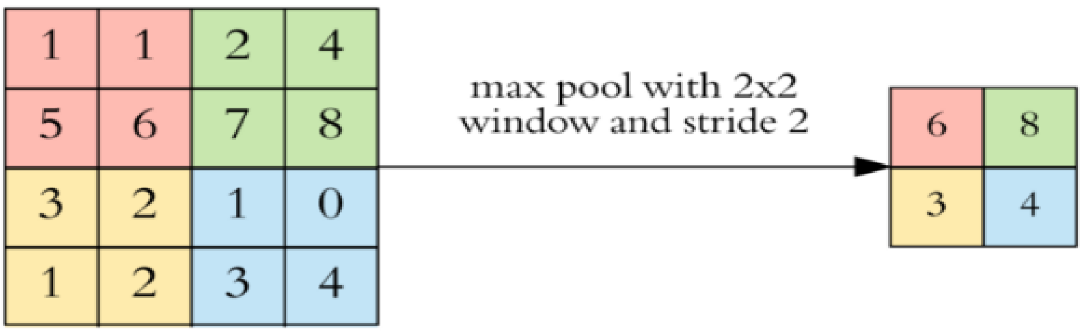

Figure-3.3.9.2.1: Max Pooling vs Convolutions [26]

Here every different color is a window where the size of window is 2*2 and stride is 2. Why do we use stride value 2 due to remove the overlapping problem. After max pooling we got our feature map almost one fourth of the main matrix. Point to be noted that in MaxPooling when our window size is 2*2 stride will be 2 and when window size is 3*3 stride will be 1.

3.3.9.3 Activation Layer

The activation layer uses an activation function, mostly used Relu that means Rectified linear unit. Relu keep positive value as it is but in case of negative values makes it to zeros. So the range of Relu is zero to infinity. In computer vision achieving better performance is near to human. Designing a CNN required great strength because CNN has no fixed rule to design it. Relu allows the network efficient computation and it is not linear.

3.3.9.4 Dropout Layer

Dropout is the most popular regularization technique. For increasing accuracy dropout technique plays an important role. For preventing overfitting dropout is used, at each iteration drop a neuron at the training time. The dropout neuron resampled at every step and active next step. We can apply the dropout in input and hidden layers. The neuron which we drop edges of this neuron will be disable and dropout can only be applied on training time not testing time.

3.3.9.5 Fully Connected Layer

Fully connected layer nothing but a fed forward neural network. The shape of a fully connected layer is like a pyramid where every node connects with all nodes into the next layer. Output of the final pooling and convolution will be the input of a fully connected layer and that is flatten. Flatten means it unroll the 3 dimension matrix of the final convolution layer into a vector.

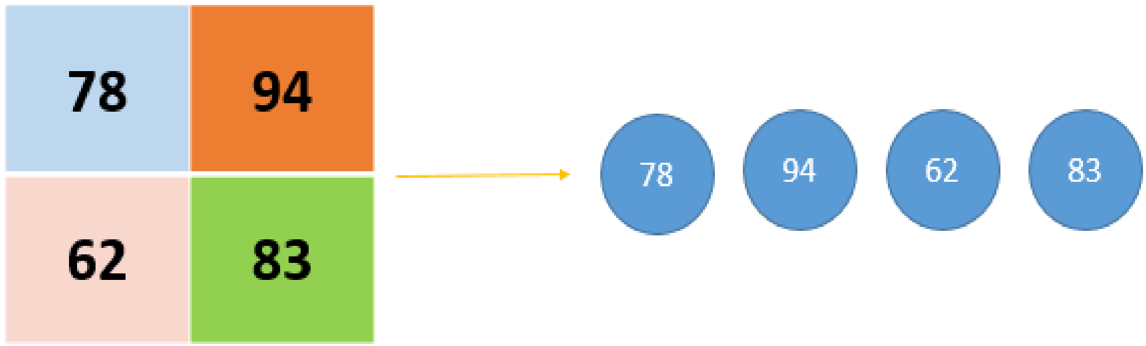

Figure-3.3.9.5.1: Fully connected Layer [25]

This flatten vector is connected with a fully connected layer that is the same as ANN and its mathematical operation. The number of nodes of a fully connected layer denotes the number of classes. If we increase the number of hidden layers our network learning ability will increase. Two or three hidden layers is enough if the pattern being passed through the network is sufficient after flatten output.

3.3.9.6 Data Pre-processing and Augmentation

As we know every algorithm has limitations although CNN can capture spatial features but its capability is limited by pattern of existing data. One feature extraction method is needed for achieving good accuracy. Training data gives good performance for over fit but in case of unseen data it give poor performance. By preprocess and augmentation we can solve the issue. Techniques such as flipping, rotation, translation, channel drop this helps create more synthetic data and make it more robust to real world unseen data and it’s give good accuracy. If we can feed more data in our model it can be helpful for archiving good accuracy. We research the particular class of images. We try to remove the noise and make it workable.

3.3.9.7 Basic Architectural diagram of CNN

CNN Architecture follows some design principle. Where the dimension of the input image decreases at every step. Data and optimization techniques that can help CNN model low dependency. Our technique is going to reverse the flow of back propagation of a CNN.

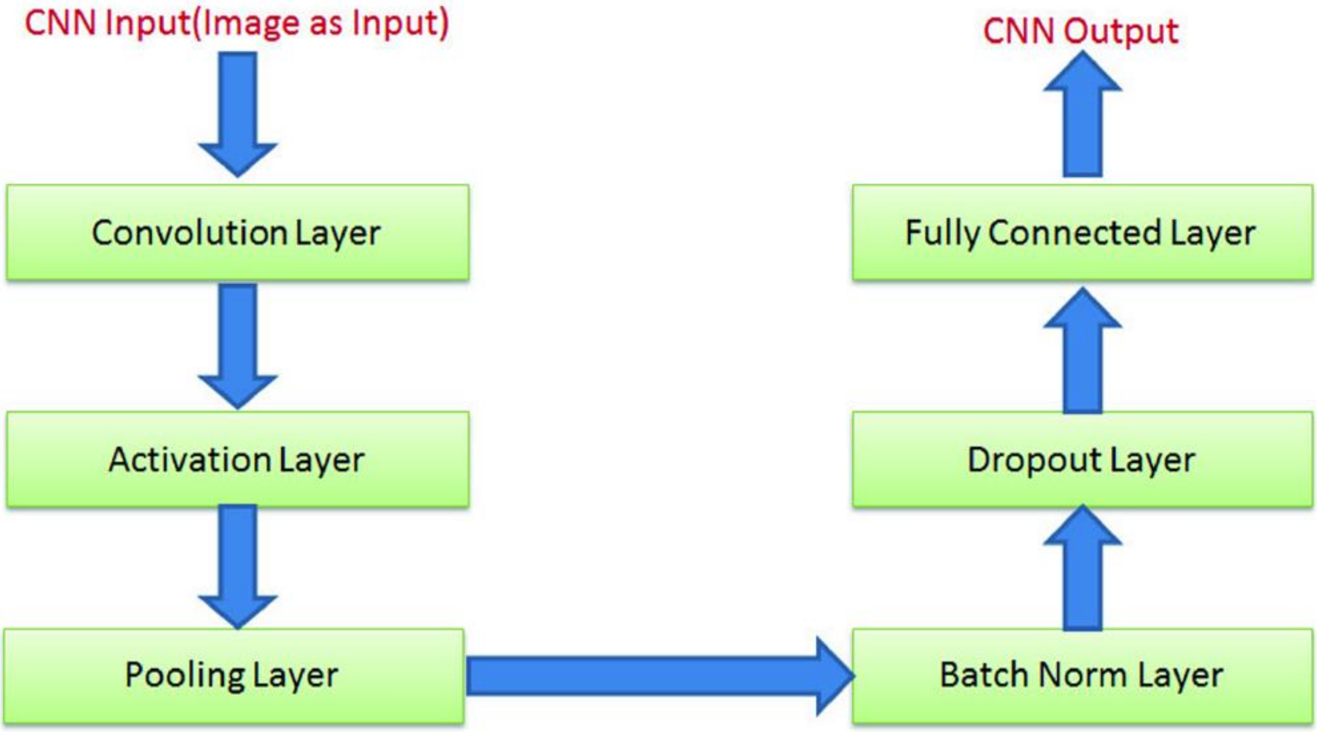

Figure-3.3.9.7.1: CNN Architecture [20]

3.3.9.8 Forward Propagation

Our main task is classification, CNN finds out the probability value of every class. If we have 4 output classes they are normalized into its probability and the maximum probability value will be the output class. It is actually very type of tasks such as image classification where the output is encoded. By reducing loss we can minimize the error using back propagation.

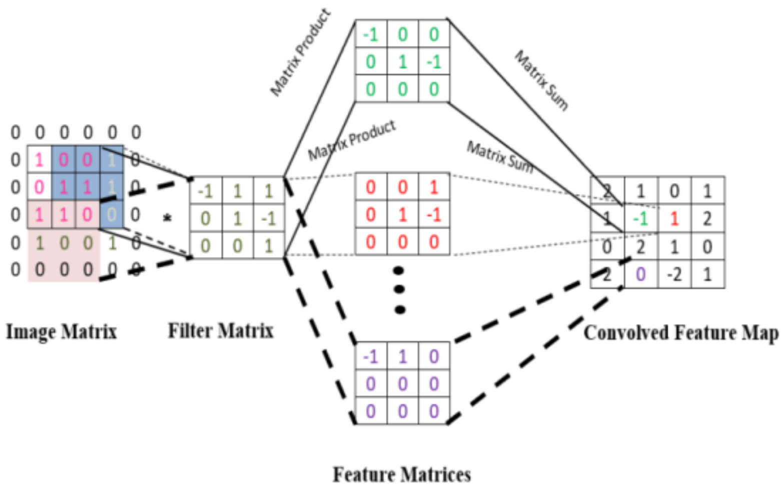

Figure-3.3.9.8.1: Forward propagation [19]

3.4 MobileNetv2 Architecture

MovileNetv2 was developed for mobile devices. It can give a good accuracy with the low parameter and mathematical operation that can help using deep learning in mobile devices. There are 3 convolutional layers in MobileNetv2. This first layer is an expansion layer it's dimension is 1x1. Its main purpose is to expand the data before going into depthwise convolution. In this layer the number of output channels is greater than the number of input channels. It's working procedure is totally opposite of the projection layer. Using expansion factors define data to expand quantity. The expansion factor is 6. If a tensor has 10 channel the first layer convert it's into a new tensor with 10*6= 60 channels.

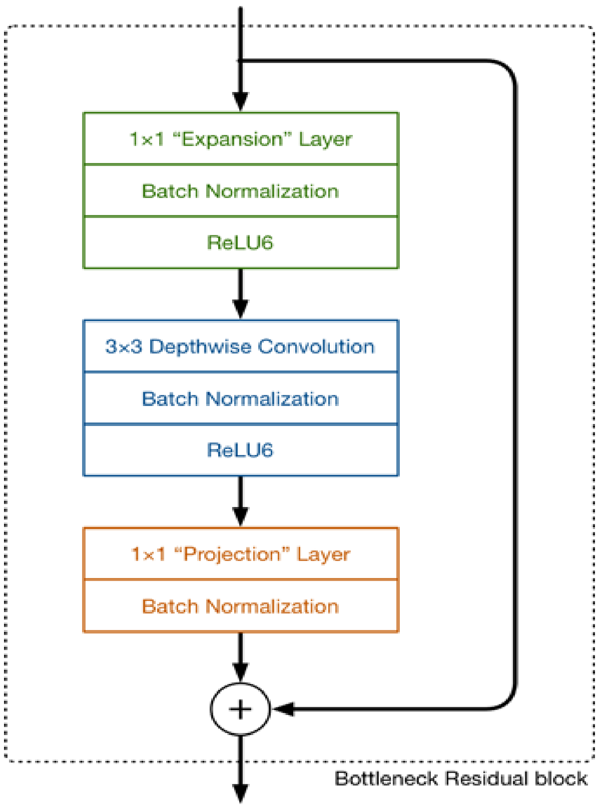

Figure:-3.4.1: MobileNet Version 2 Architecture [18]

The second important layer is residual connection. It has a working procedure similar to RestNet and helps to gradient performance. when the channels go in and out of the block then this layer is used. Second layer and third layer is as usual MobileNetv1. Each layer contains batch normalization and Relu6 as an activation function.

CHAPTER 4

Implementation Steps

4.1 Introduction

Image classification works on the basis of pixels. It is most difficult to identify the disease and recognize it. It is to find out the spots and then classify it. This model plays a very important role to identify disease where the leaves are affected.

4.2 Tools we used

When we develop any project we need some tools. As usual we use some tools for developing our project. During development which tools we use are given below.

4.2.1 Google Colaboratory as an IDE

It is an open source cloud service, it supports GPU as free. Google colab is similar to jupyter notebook. If you have a Gmail account you can run it. It does not require installation. If you work on google colab you have two options for working directory. You can use their built in memory and your google drive by mounting your drive. This is an online platform when you close the colab you have to run every cell again.

4.2.2 Tensorflow python library

Tensorflow is a deep learning library developed by google brain team. First it was not free for all. When it is getting popular google gives it for free. Tensorflow is developed using C++ for fast running. Basically it is used for numerical, scientific computation or large scale deep learning. It is also an open source library. It can train and DNN. It is used for developing several applications like image segmentation, handwritten digit recognition, sequence to sequence model and word embedding.

4.2.3 Keras python library

Keras is developed for neural networks, it is written in python and works on tensorflow. We can say keras is a sub library of tensorflow. Keras is very easy to code, it is modular, many of essential programs are modulated in keras. It was developed by google engineer Francois Chollet. Keras can handle high level API but it cannot handle low level API.

4.3 Technology used

In this modern era we have lots of technology for doing these tasks. But when we choose it we focus on our crucial tasks according to our problem we select technologies. Here we choose deep learning algorithm for image classification. There are several techniques or algorithms available but we choose CNN.

4.3.1 CNN

CNN is very familiar for image related tasks. We choose it for plant leaf disease detection and classification using image classification. This technology is very popular in deep learning. So we try to make a model that is industry standards.

4.4 Steps of Implementation

Now I will describe the implementation process.

4.4.1 Importing Libraries

There are necessary libraries which will be used to develop the project.

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing import image
import matplotlib.pyplot as plt
import numpy as np
import os
import tensorflow as tf
import tensorflow_hub as hub
```

Figure-4.4.1.1: Import Libraries

Keras is very useful for image dataset. Keras is used for data augmentation which type of data I want to preprocess. Tensorflow is used because keras only can run on tensorflow.Matplotlib is a plotting library and pyplot is a sub library of matplot that is used for numerical plot. Numpy is a scientific library that is used for matrix calculation. Numpy is used for array operation of an image. For the deep neural network keras contain all the features.

4.4.2 Rescale Images

```
train=ImageDataGenerator(rescale=1/255)
test=ImageDataGenerator(rescale=1/255)
validation=ImageDataGenerator(rescale=1/255)
```

Figure-4.2.2.1: Rescale images

We convert images into its corresponding pixel value.

4.4.3 Drive mount

```
[ ]  from google.colab import drive
     drive.mount('/content/drive')
```

Figure-4.4.3.1: Drive mount

Our dataset is in Google drive. First we should import Google drive for access permission and then mount the directory which I want to access.

4.4.4 Upload images

```
[ ]  train=train.flow_from_directory('/content/drive/My Drive/Colab Notebooks/plant leaf/train',
                                        target_size=(200,200),
                                        batch_size=21,
                                        class_mode='categorical')

     Found 4976 images belonging to 21 classes.

[ ]  test=test.flow_from_directory('/content/drive/My Drive/Colab Notebooks/plant leaf/test',
                                        target_size=(200,200),
                                        batch_size=21,
                                        class_mode='categorical')

     Found 1102 images belonging to 21 classes.

[ ]  validation=validation.flow_from_directory('/content/drive/My Drive/Colab Notebooks/plant leaf/validation',
                                        target_size=(200,200),
                                        batch_size=21,
                                        class_mode='categorical')

     Found 1742 images belonging to 21 classes.
```

Figure-4.4.4.1: Upload images

Upload the train test and validation data where target values denote image height and width. Batch size means how many bits we transmit at every epoch. Class mode is categorical because here our dataset contains more than two classes.

4.4.5 Class indices

```
{'Corn_Cercospora_leaf_spot Gray_leaf_spot': 0,
 'Corn_Common_rust': 1,
 'Corn_Northern_Leaf_Blight': 2,
 'Corn_healthy': 3,
 'Pepper_bell_Bacterial_spot': 4,
 'Pepper_bell_healthy': 5,
 'Potato_Early_blight': 6,
 'Potato_Late_blight': 7,
 'Potato_healthy': 8,
 'Tomato_Bacterial_spot': 9,
 'Tomato_Early_blight': 10,
 'Tomato_Late_blight': 11,
 'Tomato_Leaf_Mold': 12,
 'Tomato_Septoria_leaf_spot': 13,
 'Tomato_Target_Spot': 14,
 'Tomato_YellowLeaf_Curl_Virus': 15,
 'Tomato_healthy': 16,
 'Tomato_mosaic_virus': 17,
 'bean_angular_leaf_spot': 18,
 'bean_healthy': 19,
 'bean_rust': 20}
```

Figure-4.4.5.1: Class indices

We can see the class name and its indices value. It was generated by the image folder index.

4.4.6 Upload MobileNet

```
[ ] feature_extractor = "https://tfhub.dev/google/tf2-preview/mobilenet_v2/feature_vector/4"

[ ] #import tensorflow_hub as hub

[ ] feature_extractor_layer = hub.KerasLayer(feature_extractor, input_shape=(224,224,3))

[ ] feature_extractor_layer.trainable = False
```

Figure-4.4.6.1 Upload MobileNetv2

4.4.7 Model building

```
[ ]  model = tf.keras.Sequential([
       feature_extractor_layer,
       tf.keras.layers.Dropout(0.3),
       tf.keras.layers.Dense(3,activation='softmax')
     ])

     model.summary()
```

Figure-4.4.7.1 Model building

Keras has a model name sequential. When we create a it should be sequential. Keras create a flow which parameter comes after which one. The feature_extractor_layer has two layers Conv2D, MaxPool. Keras pass images layer by layer sequentially.

4.4.8 Model compile

```
[ ]  model.compile(
       optimizer=tf.keras.optimizers.Adam(),
       loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
       metrics=['acc'])
```

Figure-4.4.8.1: Model Compile

Before the train compiles the model. When we train our model, gradient descent will run in the backend. Optimizers are used to make stable gradient descent speed. Binary cross entropy is used to binary categorize every class.

4.4.9 Model training

```
Epoch 20/25
237/237 [==============================] - 24s 102ms/step - loss: 0.6775 - acc: 0.9586 - val_loss: 0.6805 - val_acc: 0.8944
Epoch 21/25
237/237 [==============================] - 24s 101ms/step - loss: 0.6773 - acc: 0.9668 - val_loss: 0.6805 - val_acc: 0.8921
Epoch 22/25
237/237 [==============================] - 24s 101ms/step - loss: 0.6773 - acc: 0.9628 - val_loss: 0.6801 - val_acc: 0.9064
Epoch 23/25
237/237 [==============================] - 24s 103ms/step - loss: 0.6772 - acc: 0.9648 - val_loss: 0.6802 - val_acc: 0.9018
Epoch 24/25
237/237 [==============================] - 24s 102ms/step - loss: 0.6772 - acc: 0.9656 - val_loss: 0.6799 - val_acc: 0.9053
Epoch 25/25
```

Figure-4.4.9.1: Model training

Train model is assigned into the history variable for further use like plotting.

4.4.10 Model Accuracy

```
[ ] result=model.evaluate(test)

53/53 [==============================] - 361s 7s/step - loss: 0.6798 - acc: 0.9038
```

Figure:-4.4.10.1

This model test accuracy is calculated by test data. The test accuracy is 90 percent.

4.4.11 Graph Plotting

After training the model first we built the model result and plotted it. First we show the training loss and validation loss and then training accuracy and validation accuracy.

```
[ ] plt.plot(history.history['loss'], label='train loss')
    plt.plot(history.history['val_loss'], label='val loss')
    plt.legend()
    plt.show()
    plt.savefig('LossVal_loss')

    # plot the accuracy
    plt.plot(history.history['acc'], label='train acc')
    plt.plot(history.history['val_acc'], label='val acc')
    plt.legend()
    plt.show()
    plt.savefig('AccVal_acc')
```

Figure-4.4.11.1: Graph Plotting

4.4.12 Plotting Result

Graph is used to visualize the model acc loss at every epoch. We can analyze the model performance using visualization.

4.4.12.1 Loss graph

This graph shows the change of train loss and validation loss. After 25 epoch training loss is very low and validation loss is higher than training.

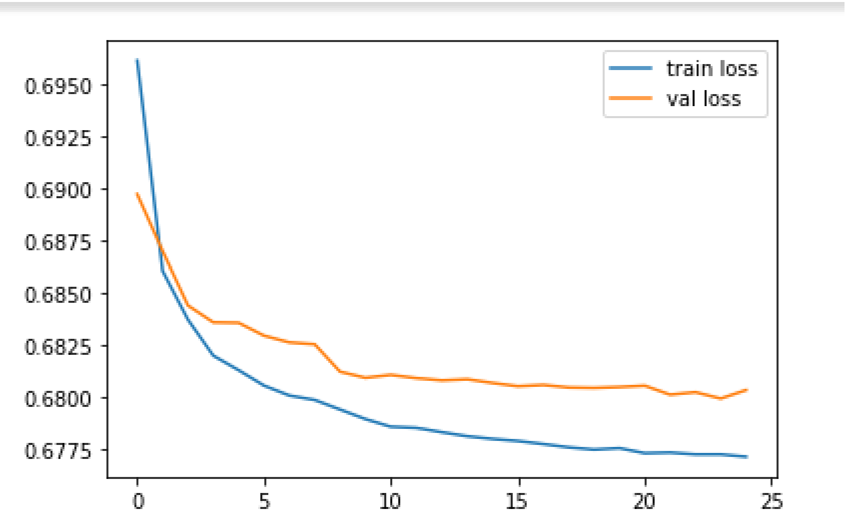

Figure-4.4.12.1.1: Loss Graph

4.4.12.2 Accuracy graph

In this graph we can see model prediction using validation and test set. Here with the increase of epoch number the training and validation accuracy increase.

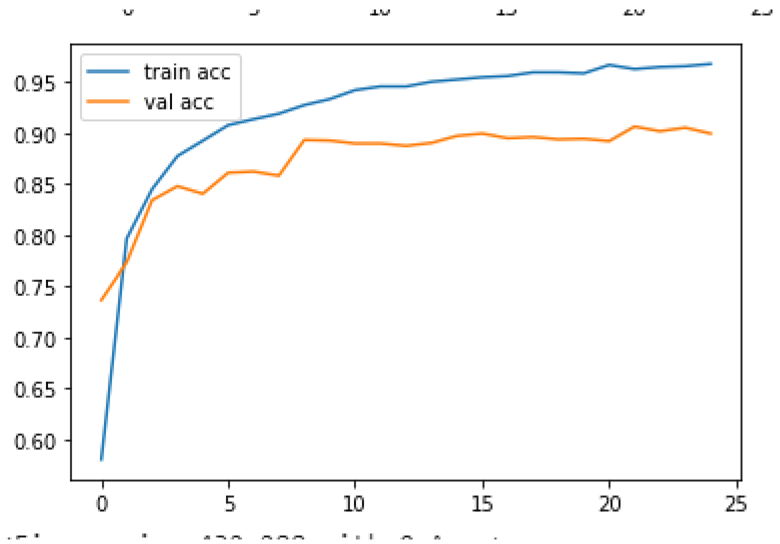

Figure:-4.4.12.2.1: Accuracy Graph

4.4.13 Upload file for test

```
[ ]  new_image=plt.imread('4.JPG')
     img=plt.imshow(new_image)
```

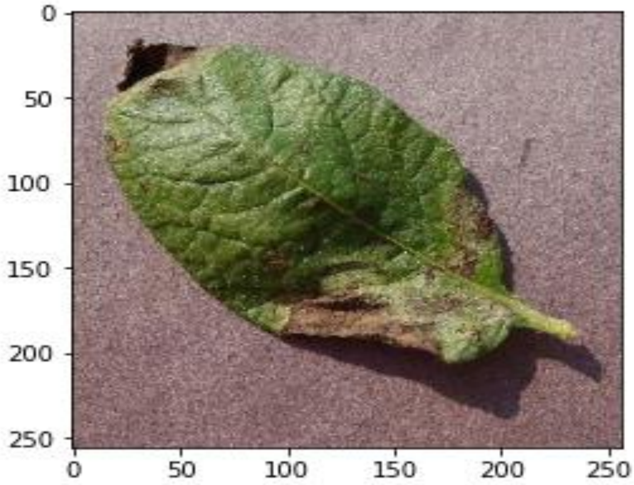

Figure:-4.4.13.1: Upload image

4.4.14 Resize the new image

We should resize the image into 224* 224. when we upload images it can be any size. If we didn't resize the image dimensions will not match, then prediction will show error.

```
from skimage.transform import resize
resized_image=resize(new_image, (224,224))
img=plt.imshow(resized_image)
```

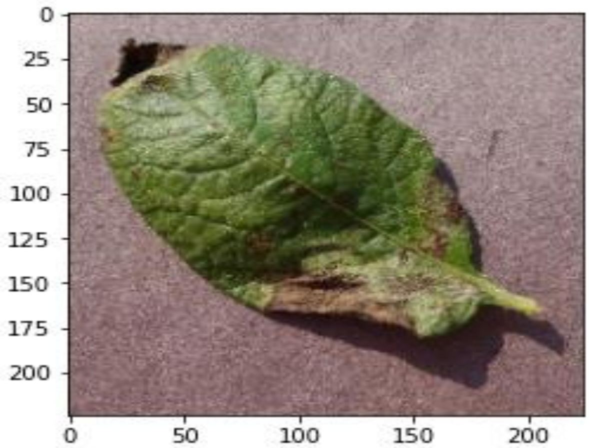

Figure-4.2.14.1: Resize new image

4.4.15 Image to array and Prediction

Here image first converts into an array for calculation purposes. Because our model works on numerical value. After converting the image into an array then predict it.

```
[ ]  predictions=model.predict(np.array([resized_image]))
     predictions
```

```
array([[2.0396563e-05, 1.8277886e-05, 3.3425658e-07, 3.5911045e-05,
        1.5871571e-02, 9.8242742e-01, 2.1022947e-04, 7.1317827e-06,
        1.5455619e-06, 8.6508819e-04, 8.4801330e-05, 1.0983661e-05,
        8.9672831e-05, 2.2741340e-05, 1.3410093e-04, 4.4567139e-05,
        2.5407751e-06, 2.1797960e-07, 7.8759325e-07, 1.4620963e-04,
        5.4205161e-06]], dtype=float32)
```

Figure-4.4.15.1: Array & Prediction

4.4.16 List indices of classes

It shows the indices which class is near to the image.

```
[ ]  list_index=[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21]
     x=predictions

     for i in range(21):
       for j in range(21):
         if x[0][list_index[i]]>x[0][list_index[j]]:
           temp=list_index[i]
           list_index[i]=list_index[j]
           list_index[j]=temp
```

```
[ ]  print(list_index)
```

```
[5, 4, 9, 6, 19, 14, 12, 10, 15, 3, 13, 0, 1, 11, 7, 20, 16, 8, 18, 2, 17, 21]
```

Figure-4.4.16.1: Indices 0f Classes

4.4.17 Final Output

We can see the final output of the image. Here every class will show their probability values according to descending order.

```
[ ] for i in range(21):
      print(classification[list_index[i]], ':' , predictions[0][list_index[i]] * 100 )
```

```
Potato_Late_blight : 96.89304232597351
Tomato_Leaf_Mold : 2.398313023149967
Tomato_Early_blight : 0.23183745797723532
Tomato_Late_blight : 0.2182484371587634
bean_rust : 0.09301775135099888
bean_angular_leaf_spot : 0.06202129297889769
Tomato_Target_Spot : 0.04355228447820991
Tomato_Septoria_leaf_spot : 0.028063892386853695
Potato_Early_blight : 0.017212601960636675
Tomato_Tomato_YellowLeaf_Curl_Virus : 0.006458316056523472
Tomato_healthy : 0.0030627987143816426
Pepper_bell_Bacterial_spot : 0.003025491241714917
Corn_Cercospora_leaf_spot Gray_leaf_spot : 0.0014983053915784694
Corn_Northern_Leaf_Blight : 0.0003115729214187013
Tomato_Tomato_mosaic_virus : 0.00026122772851522313
Potato_healthy : 5.834306762153574e-05
bean_healthy : 1.591321705518567e-05
Corn_Common_rust : 5.135176195381064e-06
Corn_healthy : 3.3592236547974608e-06
Tomato_Bacterial_spot : 1.6524364099268496e-06
Pepper_bell_healthy : 5.623161047907388e-07
```

Figure:-4.4.17.1Final Output

CHAPTER 5

RESULT AND ANALYSIS

Flows of this work include image classification technique. After a survey we decide to select methods to get good results. We choose to update technology to solve this issue. We collect data from several plants to visualize the solution. After we write the effective code to make a model for good results. This model gives us effective results with accuracy 90.38% .Our main goal of this project is to detect whether the leaf is affected or not. This task is not easy because we use different kinds of crop leaves and the data we collect from the crop field that's why we know the environment condition. So, we have a proper knowledge about this leaf. We hope our model can help farmers because we used a perfect dataset that is being properly classified. A good dataset is the first solution for getting good accuracy. All analysis based on these dataset. Image processing is a very big task when the number of classes is more than 20.We get our expected outcome our model gives a good accuracy and it can work effectively. We hope that our model will give good results for further data sets. We all know for any work there is an opportunity to improve it. It might work well on new dataset when the samples of this dataset are proper or effective and it will give good accuracy for classification purposes.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

There are various techniques for image classification but to analyze and compare one to others we think CNN is one of the best techniques for classification. We survey deeply and compare the advantages, disadvantages, model complexity and computation for each technology than we thought CNN is our best choice. We explain in detail every layer of CNN which layer did which job. Our dataset is an organized collection. First we create a train test and validation folder into our root folder, every folder contains the every class of image. We manually split data into these three folders. After preprocessing rescale the data to pixel value that are 224*224. After rescaling we upload mobile net feature extractor layers that usually contain two layers one is Convolution layer and another one is MaxPool. In the convolution layer we make a feature map matrix. Max Pool is used to reduce the dimension of an image. We create our model sequentially and compile it and finally predict the image. CNN's workflow is done by layer by layer. We explain how CNN can help us in our daily life and mention the applications that are most familiar nowadays. We have a huge opportunity to make an automatic monitoring system using CNN. This work we study various image classification techniques and compare them one to another we found CNN works better than others.

6.2 Future Scope

We use MobileNetv2 to deploy this project into the mobile version. We can use it as an embedded application. We will add more data like vegetable leaves. For the large scale open field cultivation we can use real time monitoring using drones and other autonomous agriculture vehicles.

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APPENDIX

Appendix A: Survey form for Farmer

<u>Respondent Information:</u>

Respondent Name :
Address :
Crop name :
Date :
Time :

Disease Name	Visibility			Solution	
	Clear	Blurry	Very Blurry	Known	Unknown
Corn_Cercospora_leaf_spot Gray_leaf_spot					
Corn_Common_rust					
Corn_Northern_Leaf_Blight					
Pepper_bell_Bacterial_spot					
Potato_Early_blight					
Potato_Late_blight					
Tomato_Bacterial_spot					
Tomato_Early_bligh					
Tomato_Late_blight					
Tomato_Leaf_Mold					
Tomato_Septoria_leaf_spot					
Tomato_Target_Spot					
Tomato_YellowLeaf_Curl_Virus					
Tomato_mosaic_virus					
bean_angular_leaf_spot					
bean_rust					

TRANSFER LEARNING APPROACH FOR PLANT LEAF DISEASE

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