

DESIGNING DISEASE DETECTION MODEL USING CNN APPROACH FOR CORN CROP PLANTS AND COMPARING IT WITH EXISTING PRE-TRAINED MODELS

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Abstract

From the beginning of human civilizations agriculture is the main occupation of human beings dealing with various factors associated with agriculture. The main objective of the agriculture is to cultivate the crops to fulfill the human requirement in different season. These crops not only fulfill the need of humans but also feed their domestic animals. Agriculture helps in growing plants for these crops that produces various grains and vegetables to fed humans but also produces crops like cotton and Jute that produces fiber which was used in manufacturing clothes wear by humans. Quantity and quality is associated with agriculture produce as it was observed by the humans which helps them in deciding fertility of agriculture land, which crops generates more yields in which season and deciding the seeds for crop. The quality of agriculture produces were directly linked to its economic value and quantity is directly linked to the prosperity of the farmers, the person who are associated with agriculture. Each crop suffers from various diseases that deteriorate both the quality and quantity of the crop yields. These diseases were caused due to various micro-organisms like bacteria and fungus, causes loses to the farmers as they affect the crop produces.

To reduce or eliminate the effect of diseases from their crops and to maintain both quantity and quality of the crop yield, farmer uses various techniques. These techniques include use of ashes of Cowdung and neem tree (*Azadirachta Indica*) to the various chemicals like DDT, gammaxene and pesticides etc. But the excessive use of chemicals not only disturbs the ecological balance and extinction of several species of both flora and fauna. Also now pesticides are no longer effective on new generation of diseases. These diseases now develop immunity towards the pesticides used by the farmer. Now days farmer may use various techniques and tools developed by Information Technology and may avoid lose caused to them by various crop disease. These tools may includes the various machine learning models that have the ability to find the crop disease in its beginning and precise use of specific pesticides to control the disease. These models are developed by researchers for specific crop and for some specific area. We propose a model for Maize crop and named it as M-net. We compare it with other existing models. In last part of the paper, we generalize the M-net model so that it could be used in other similar crops. We here discuss the use of Transfer learning methods.

Keywords— Artificial Intelligence, Machine Learning, Deep Learning, Crop Diseases, Maize

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INTRODUCTION

Agriculture is one of the ancient professions associated with human civilization and backbone of the economy. It helps human beings to settle down in colonies from the caves and jungles. Most of the ancient human civilizations are settled near the river or any other water body. Agriculture includes cultivating the crop's, collection of fruits, collection of plant products and process them to fulfill the need of food, clothes and houses not only for themselves and their counterparts, also for their domestic animals. [1] Agriculture yields either fruits or a crop suffers from the diseases caused by microbes (micro organisms) like fungus, bacteria, virus etc. These diseases not only decrease the yields of crops but also significantly reduce the quality of the yields. That affects the earnings of farmers and its social impact was the rise of prices of that particular crop. These diseases are caused by microbes but sometimes environmental factors or some types of soil are responsible for the growth of diseases causing microbes. They causes different kind of diseases like powdery mildew, blight, common rust, stem rot, septorial leaf blotch etc.

Earlier diseases in the crops considered to be curse of the God's and for removing which farmers perform different activities like ploughing land with silver or gold plough, or ploughing it manually instead of using any domestic animal like OX who cannot buy the silver or gold plough etc. according to the culture of the area. These crop diseases not only affect the crop yields but also the social and economically well being of the farmer's family and their social status. Sometimes diseases in the crops may be caused by the nature of the soil and its fertility. [2] From then onwards fertility of the soil and environmental conditions becomes important factors that may cause the diseases in the crops. To improve the fertility of soil farmer starts the crop rotation, then the use of organic or bio fertilizers and chemical based fertilizers. [3] The use of Chemical fertilizers increases the yield of crop but the chemicals start penetrating into the ecosystem. Hence disturbing the natural food cycle and some animal species are extinct from their ecosystem. Same is with pesticides used by farmers to control and eliminate the disease from crop plants. Farmers use these pesticides without knowing their ecological impact but only want to control the disease that harms its crop. With passage of time the microbes that causes the disease in crop plants becomes immune or resistant to the pesticides used by farmer.

Most of the maize or corn crop diseases were caused by micro organisms like fungus, bacteria, algae etc. which could if identified in its beginning can be curable by proper amount of pesticides thus maintaining the quality of the crop.[4][5] In India it was difficult for small farmers to access the services of plant pathologists as there number is very less and most of them are situated in cities or urban areas. Moreover for identification of disease in maize crop requires their several physical visits to the field. These visits should be made by plant pathologist if not in a week but within a fortnight or fifteen days. [6] Due to communication revolution in India most of the small farmers or their family members possess at least one smart phone that could be used as a tool for fast and timely interaction. Other Information technology tools like Machine Learning, Deep Learning and Transfer Learning could be used by farmers to timely identify or detect the diseases in their crops. These technologies are not only able to find the diseases in crop plants but are accessible to each and every farmer. Some of the tools even guide the farmers which crop is more suitable to their fields and the possible diseases in crop plants by considering parameters like soil nature and environmental conditions.

With emergence of new technology like machine learning and deep learning that problems or issues which were not resolved earlier now could be solved in finite time. These technologies could be used in multiple domains like health care, agriculture, robotics, space science etc.

Even in the agriculture sector for various activities specifically like disease detection that not only helps the farmer in increasing the yields of the crop but also its quality. Classification of diseases in maize crop is an important process which could easily be completed by machine learning algorithms. [7] The infected leaves of the maize crop plants could help in identification of crop disease and the agronomy or structure of maize crop plants helps machine learning algorithms in evaluating the state of plant. Earlier identification of disease in maize crop plants should make the farmer to implement adequate steps in controlling the disease in crop plants. The problems in agriculture could be resolved by machine learning algorithms and helps in maintaining food security which is important for any nation. The learning in machines could be supervised, unsupervised, reinforcement and semi-supervised that helps them to resolve the problems. The main objective of using these techniques in agriculture sector is to increase the income of farmers not only by reducing the cultivation cost but also improving both quality and quantity of the crop yields. It was only possible by detecting early the disease in crop plants and regularly watching the health status of the crop plants from its germination to final production.

Modern day farmer uses techniques and tools based on Artificial Intelligence, so that they could identify the crop disease in its beginning and use the right amount of pesticides to control them. These tools are more specifically based on Machine Learning and Deep Learning; both are subsets of Artificial Intelligence. The main objective of these tools is to improve the quality and quantity of crop yields per hectare and also by incurring the minimal cost in cultivation of the crop by farmer. The predictions of these models are up to 95% accurate and model which is accurate with wheat is not suitable for paddy or other crops. [8] In various Deep Learning models like AlexNet, ResNet, VGG-16 etc. and even in the Machine Learning based models, data set emerges as one of the crucial factor in development of the model. Sometimes it is readily available for common crop and if it is not available then we have to create it which requires a lot of time and effort of the developer. As the crop agronomy is different from other crops and their diseases. Therefore model suitable for one crop and may not be suitable for another crop. It is not feasible to develop models for each and every crop. But if learning of one model is incorporated into another model, such process is called Transfer Learning. The models based on transfer learning approach are feasible both economical and operational.

Picture below represents another common disease named as common rust in maize or corn crop caused by fungus called Puccinia Sorghi. It appears on both side of the leaves and moisture in the environment provides the suitable conditions for its growth and spread to other crop plants. The infected corn crop plants consists of the powdery pustules [9] on single or both surfaces of leaves with brown to dark brown color which is converted to brownish black on maturation of the crop. Therefore any model based on machine learning and deep learning should also consider the environmental factors specially the moisture in surrounding environment. In worst case it affects maize or corn crop yields as it causes crop plants to die as it target the new leaves of crop plants. Hence the disease in corn crop affects its yield and also the quality of the crop, so it was controlled in its beginning. This disease spread to other plants and fields with the help of wind as it consist of uredospores which can't be seen by the naked eye.

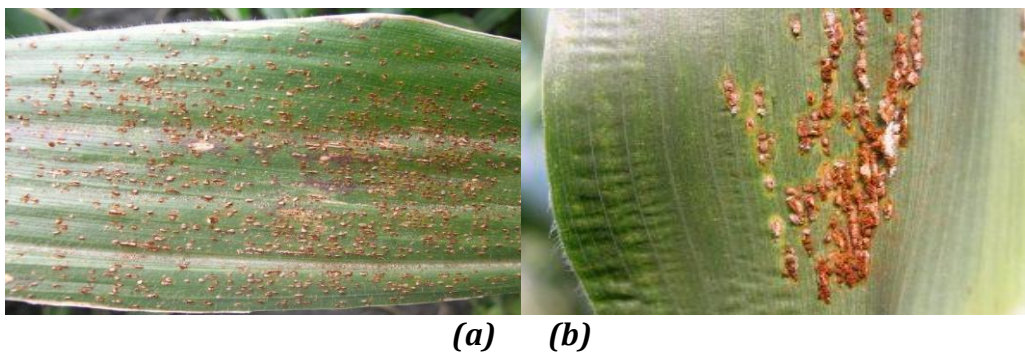


Figure-1 Maize crop suffering from Common Rust

The model proposed in the paper is named as M-net model which was based on Deep Learning algorithms like convolution neural network (CNN) and models like VGG15 and Alex-Net. It not only identifies the diseases that may commonly occur in maize or corn crop and easily accessible to farmers. The M-net works on the structure of leaves of crop plants as well as includes environmental factors like moisture or humidity. The symptoms of these diseases are identified through the leaves images of the maize crop. The maize crop is one of the vastly grown crops in different part of worlds. It is important for human beings for its nutritional value and waste of this crop are used to feed domestic animals. Diseases commonly occurring in the maize crops are: Blight, Common Rust, Black Rot and Charcoal Rot, Downy Mildew etc. These diseases affect both the quality of the crop and quantity produced per acre of land.

RELATED WORK

Researchers working in the field of identification of maize or corn crop disease in its earlier phase use different methods based on diseases symptoms. [10] They use different machine learning methods providing different accuracy in identifying the corn diseases with small to large datasets. Probabilistic Neural Networks (PNN) along with image processing used by Chen and Wang to identify the maize crop diseases got an accuracy of 90.4%. [11] The major limitation of the PNN used is its speed and requirement of large datasets. Xu et al. with their method of maize leaf disease detection achieves the accuracy of 94.71% based on multi classifier fusion based on adaptive weight of maize leaves. [12] Zhang and Qi et al. in finding maize leaves diseases accurately up to 95.3% with their model based on multiple image processing methods combined with different features of maize leaves [13] but not suitable for real world due to its variation in accuracy. PCA (Principal Component Analysis) is another method used by researchers to find the disease in corn crop plants to get more accuracy even with the small data sets. Niketa and Leisa used data mining to solve certain problems of cultivation like disease identification and harvesting of the crops and predetermine the yields on the basis of previous year's production. To identify certain climate factors that affect the yields of crop most using machine learning algorithms that causes stem sprout's attack were discussed by Romadhon [14] in his paper. Districts having more stem sprout's attack than other are called endemic district's. He computes average coefficients of five environmental factors which are maximum temperature, minimum temperature, average temperature, air humidity, rainfall and rainfall season. A team of researchers uses KNN and feed forward neural network to predict the days when there is high chance of infection in crop plants by using climate datasets of last 10 years. Nagini, Rajni and Kiranmayee conducted research to predict yield of crop per hectare using various regression models. The crop yields are measured in tons per hectare are predicted by linear regression and ridge regression. [15] Due to global warming there is increase in average day and night temperature during the

grain yielding season which directly or indirectly affects the quality and quantity of the crop yield. It causes development of different crop plant diseases on both surfaces of plant leaves which results in reduction of carbon capture, reduction in enzymes activity that causes conversion of sugars to starch and imbalance between various hormones. In past decade traditional grain phenotype is replaced by automated image based grain phenotype to predict plant environment interactions with low cost and high accuracy. These automated approaches were based on KNN, SVM, Mask R-CNN and CNN etc. Some researchers also explore the remote sensing; infra-red thermal imaging, geographic information system and global positioning system. These systems are useful in forecasting the crop diseases that may occur but could not identify the disease.

The complex structure of network created by multiple interconnections of processing units that learns or studies from the input data is called Artificial Neural Network (ANN). It is inspired from human brain which consists of neurons and dendrites. The dendrites provide connection between multiple neurons that could be referred to multiple inter connections and the processing units are referred as neurons. When ANN has multiple layers of neurons than it becomes deep neural network where each layer it possesses represents conducting different tasks. For conducting a task ANN requires large amount of datasets and huge computational power. ANN provides the basis for implementation of convolution neural networks (CNN) that could be utilized for different domains. The power of deep learning improves when non linear modules are implemented over multiple layers and the availability of hardware resources like GPU's, TPU's and cloud computing. Deep learning uses complex predictive functions based on the dataset used to improve its power further. Steen et al. in the year 2016 is able to obtain the precision of 99.9% in detecting the obstacles that comes before the farm machinery by using the deep learning. To count the number of fruits or flowers in 2017 Rahnemoonfar and Sheppard provides a viable solution in digital way again using the deep learning methods that gradually replaces the traditional methods. The DCNN model in 2016 is able to identify 13 different types of plant diseases using leaves features of the plants.

Models based on deep learning algorithms provide more accuracy in identification of maize leaves diseases but they require a large dataset of images which helps not only improvement of accuracy in identification of leaves diseases but also its utilization of these techniques in agriculture sector. The Expert Systems are developed for disease identification especially in crop plants are based on deep learning. Expert Systems are considered to be the first commercial success in Artificial Intelligence using different AI based techniques to solve the particular issue or problem in given domain like agriculture. These Expert Systems not only assists the farmers in identifying corn crop diseases but also with high accuracy and preciseness. The selection of right features is crucial in design and development of these systems. These Expert Systems requires large datasets, training time and huge hardware resources like computing power for their implementation. To reduce the hardware resource requirements and training duration, now days most of the researchers in this domain uses deep learning methods. These methods achieved more success in comparison to others but take longer duration and highly accurate datasets in finding the diseases in maize crops. In convolution neural network (CNN) algorithm based model achieves accuracy of 98.3% in detection of diseases in potato crop as conveyed by Md. Al-A Amin et.al. in their paper [16], Lu et al. [17] proposes model to identify leaves diseases in paddy crop based on CNN were able to achieve 95.48% accuracy where as Dechant et al. in his model to find northern leaf blight in maize or corn crop achieves accuracy of 96.7%. [18] The use of deep learning methods is possible only due to the huge computational power offered by the NVIDIA processors and Google, in order to identify the disease in maize crop plants and comparing the newly

developed model with existing ones and traditional approaches. LeNet-5 which was designed in 1989 and based on CNN to identify the handwritten zip code digits by LeCun and his team using neural network architecture. [19] This means that convolution neural network is available with us for its implementation in different fields. Earlier computer vision activities are implemented through image classification but after 2012 mostly they are implemented with the help of CNN or models based on it. In the models like Histogram Oriented Gradients (HOG) and Scale Invariant Feature Transform (SIFT) [20] are designed to extract features from the images is a tedious process that requires expertise in that domain or field. Right features must be selected in the model to solve a particular problem/issue or task whereas CNN can extract features from the images with the help of various layers present in it and design the model on them.

Selection of the important parameters and critical factors are required for designing of perfect model that was based on CNN architecture. The deep learning models were used to identify the diseases in maize crop using the features like image displacement, distortion and scaling. Deep learning becomes standard for image classification due to which it was feasible to identify various diseases only by studying their leaves in crop plants. Saeed et al. develops model based on fusion of Partial Least Square (PLS) regression and features derived by the CNN model that obtains accuracy around 90.1% in identifying the diseases in tomato, potato and corn crop. [21] The main advantages of this model were reduction in computational time and improve recognition. The model designed above uses both color and texture together in order to identify leaf diseases in any crop plants. Most of the automated systems took the help of chromatic segmentation of leaf. Hyper spectral imaging [22] is used to design and develop a model that could identify the various crop plant diseases especially for capsicum plants but it is not economically viable for small farmers and the equipment used in this procedure generates radiation that would harm the crop plants. Most of the researchers working in the field of disease identification in crop plants through their leaves using convolution neural network (CNN) had attain the accuracy more than 90%. Makantasis and Doulamis, used deep learning methods in classification of map data and obtain a score of 99.53% in classifying that class. [23] It has been observed by researchers that there should be a system based on deep learning for identifying the crop diseases especially for maize or corn crop and must be accessible to small farmers. These are the persons that suffer a lot.

RESEARCH GAPS

On studying various research articles related to disease detection using information technology written by scientists across the globe. Author's find out that there is no model developed with generalized features and used with multiple crops like model for corn crop is also applicable on sorghum or Jowar. It means the model should be suitable not only for the crop it was designed but also for the crops having similar features. These models were really helpful for farmers. Sometimes the required dataset for a specific crop is available but if it is not available or present in less count the model developed does not provide the accuracy in disease detection for that crop. It was not possible to develop model for each and every crop not only because of the availability of data but the time and cost associated with it.

MATERIALS AND METHODS

A. Dataset Description

To conduct the identification of corn or maize diseases using their leaves structure with the help of deep learning especially the convolution neural network (CNN) and the models like Alexnet and GoogleNet [24] based on it. In the proposed model (M-Net), author uses the data

set from kaggle which comprises of 4188 images. It consists of 1146 maize leaf images for blight disease, 1306 maize leaf disease of common rust, 574 images for gray-leaf-spot and 1162 healthy leaf images of maize or corn crop. Fewer amounts of data may restrict the development of good and efficient model for identifying the diseases in maize crops and generalize it by preventing it from over fitting. To overcome this augmentation on images are performed which not only increases the quantity of datasets but also efficient learning of the model. Image augmentation is performed by authors for increasing the dataset that includes the common augmentation techniques like flipping, rotating, resizing, random local rotation (RLR), cropping and generative adversarial network (GAN) etc.

B. Methodology

M-Net model designed and developed is based on the convolution neural network (CNN) and untrained models like InceptionV3, Resnet-18 and Densenet etc. The model is designed to find and forecast the diseases of maize or corn crop plants. The research methodology of the M-Net model was:

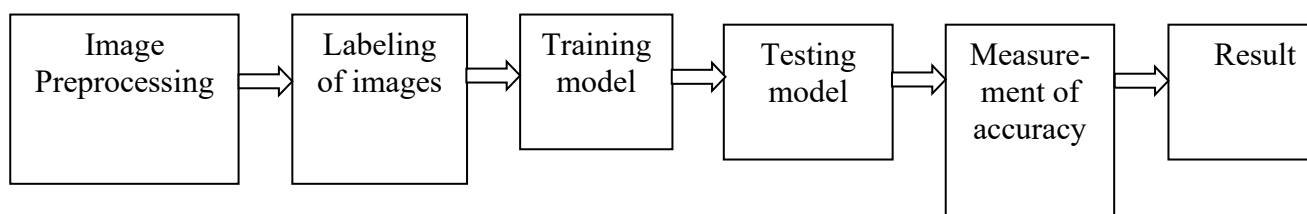


Figure-2 Block diagram of M-Net model

Various steps or phases of M-Net model specified in above diagram are illustrated in the coming paragraph. In image preprocessing step, images are gathered, augmented and noise is removed from them. The images collected are resized to 150*150 pixels, so that they follow the certain standard. Then this output is transferred for the labeling to classify the images according to the maize diseases and then the dataset is divided for training, testing and validation. After training and testing of M-Net model its accuracy is measured in comparison to other models.

C. Architecture

The model proposed by authors is M-Net model that was based on CNN model and used to identify the common maize or corn crop diseases in order to increase the quantity and quality of the crop yield. The architecture of the M-Net model uses filters of different numbers in different layers of convolution such as 32, 64, 128 and the activation function. Filters of number more than 128 are not used in the model to reduce the complexity and improve its performance. The architecture of model uses three max pooling layers of size 2x2 and two fully connected layers are used. First layer that is dense layer consists of 128 filters and second dense layer consists of equal number of filters and outputs that is four (4). Figure 4 describes the M-Net model architecture. It consists of the following components:

1) Convolution Layer: As M-Net model for corn crop disease identification is based on CNN and the main building block for the model. It consists of set of filters of different sizes to perform learning by using mathematical function between input images and filters. The use of learnable filter is convolved across the width and height of the input image by using mathematical function to produce two dimensional activation map of that filter. The convolution layer is responsible for deriving feature maps of the filters from the images used in that problem. For example the operation on convolution layer is given by-

$$CO=f(W_i * X)$$

where X is an input to convolution layer, f is activation function used, W is convolution kernel and i represents the convolution layer. W_i^k of size $M \times M \times N$ is a weight matrix and k represents the kernel number, M represents the size of window and N represents the channel number. [25]

2) Activation function: The mathematical function applied on each neuron or node present in a layer to determine the output based on its input.

$$ReLU(x)=\max(0, x)$$

These functions are crucial for neural network to perform the complex computations and classification based on non-linearity, transformation and differentiability. The proposed M-Net model uses Rectified Linear Unit (ReLU) as activation function to overcome the problem of gradient dispersion and to improve the accuracy of the model.

3) Pooling Layer: Layers in convolution neural network that reduces the dimension of images and usage of computing resources. The features or parameters are effectively and efficiently reduced by using the dimensionality reduction, translation invariance and parameter free operation. The features of regions where maize diseases are impacted most are computed by using statistical methods that help in reducing the parameters derived from images. These pooling layers could be max pooling, average pooling and global pooling. In this model (M-Net) uses average pooling which could be written as: $AvgPool(F) = \frac{1}{P \times P} \sum_{i,j \in P} F(i, j)$

where $P \times P$ represents the size of pooling window

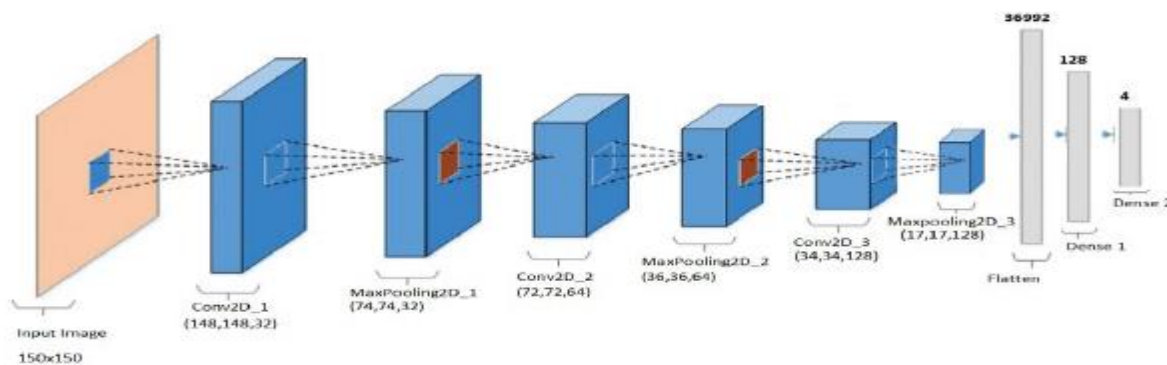


Figure-3 Different steps involved in proposed M-Net model

4) Adam Optimizer: It is most popular optimizer used in deep learning models due to its ability to tackle the problems raised by sparse gradients, adaptive learning process in robust and efficient way. The optimization algorithm is used in deep learning to optimize the parameters despite using the classical stochastic gradient procedure which is slow and uses more resources. Adaptive Moment Estimation (ADAM) uses the advantages of other algorithms like AdaGrad and RMSProp. Adam was used as optimizer in M-Net model with features of adaptive learning rates, computational efficiency and less tuning of hyper parameters are required.

5) DropOut: M-Net uses Drop Out technique or method is a regularization process in deep neural networks to prevent over fitting and improves the generalization of model but it also suffers from the limitations like longer training time and tuning of hyper parameter. It can be used on every layer of neural network except the output layer. In M-Net model each

convolution layer will prefer to have a lower dropout rate that is between 0.1 and 0.3 while the standard dropout rate is between 0.2 and 0.5 for fully connected layers.

D. Parameters of a Training Model

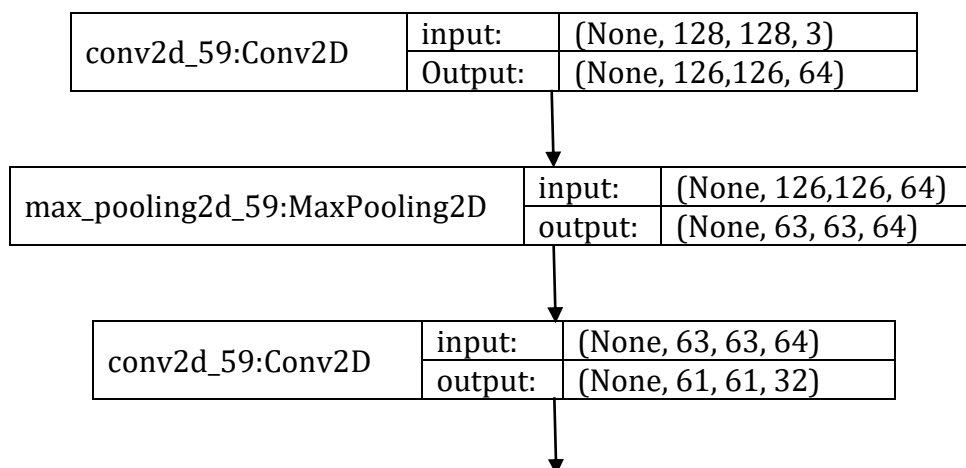
The model proposed by authors for disease identification and finding in maize or corn crop has the following features or parameters like learning rate, batch size, epochs etc. These parameters and hyper-parameters are essential for efficient training of the model. Each time the proposed model takes a decision learning rate and weights attached with neurons is updated. In the proposed model author uses the batch size of 32 and the number of epochs were 30. Each epoch in the proposed model controls the training and ensures that it passes from the complete dataset where as shuffle involves the shuffling of entire dataset after completion of the one epoch.

E. Analysis and Evaluation tools

Analysis, design and evaluation of proposed model is done with the help of Python programming language and various libraries like tensor flow, pandas, pytorch and scikit etc. The current versions of all of these are used. The jupyter notebook is used for writing python codes that could be accessed both offline and online. In offline mode we uses Anaconda framework and for online mode we uses Google drive for storage of dataset. Google Colab environment or NVIDIA GPUs were used for training and testing the proposed model with given data-set. Computer system with Intel i7 processor or equivalent, 8Gb of memory, NVIDIA GPUs with Windows 10 operating system was used for training and testing the model.

MODELS

Proposed model M-Net based on deep learning technique of CNN (Convolution Neural Network) where multiple fully connected layers was used. In designing the model author uses the latest hyper-parameter tuning mechanism like optimizers such as Grey Wolf Optimizer instead of standard Adam optimizer. These were introduced by author for generalizing the model and identifying the features suitable for it by using trying and testing mechanism. This process is time consuming but provides more accuracy not only on the selected data set but also for the random data set collected by author from real world. It is able to diagnose the various diseases of maize or corn crop that shows the symptoms on leaves of the plant. The model was generalized to identify the common maize diseases and could be applied for other crops. The model should identify the maize crop disease with a degree of preciseness and accuracy. The graphical representation of proposed M-Net model is given below:



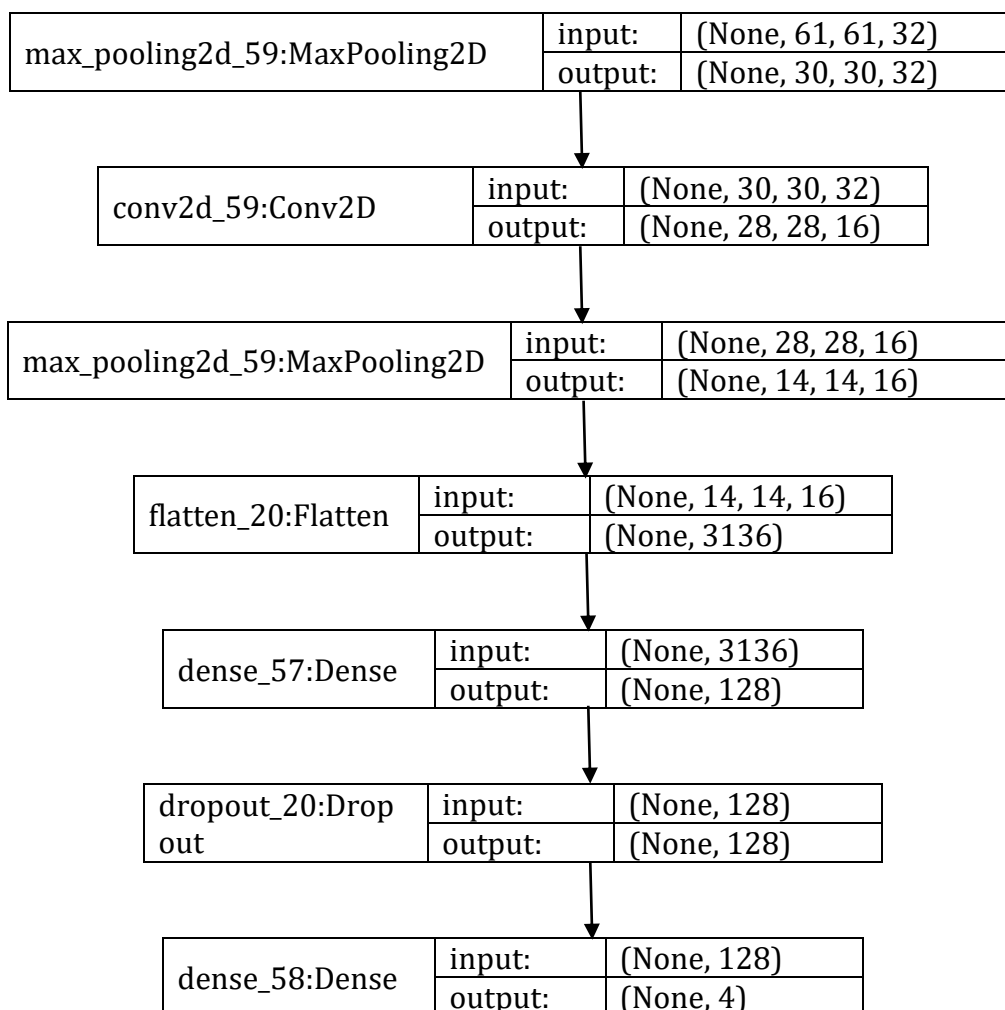


Figure-4 Proposed M-Net model

It consists of three convolution and max pooling layers with two fully connected layers. An image of the size 128 x 128 are entered into the model in order to extract features from them and if size of the image varies than it is the responsibility of pre-processing to convert the image size to standard. Loss in the model is computed by categorical cross entropy method whose equation is:

$$L(a, y) = -(y \log(a) + (1 - y) \log(1 - a))$$

Where L represents loss, y is the original class or sample and a- is sample prediction by the model. The model uses certain hyper parameters to like activation function, epochs, batch size etc. The hyper parameters used in the proposed model with their standard values are given in the table below.

Table 1. Values for hyper parameter for M-Net model

Hyper parameters	Range	Default Value
No. of hidden layer	2- 256	8
Dropout rate	0.4-0.6	0.5
Network weight initialization	Default	Glorot uniform
Activation function	Any	Relu
Learning Rate	0.001-0.009	0.001

Momentum	0.111-0.999	0.999
Number of epochs	10-1000	1000
Batch size	32-64	64/32

RESULT AND DISCUSSION

There are two important components in the designing and development of M-Net model are training and testing. The computer system on which model is trained must be equipped with GPU or TPU processors, 128 GB memory with more refresh rate or developer have access to Google Co-lab with paid usage. The results obtained by the author during training and validation of the model were incorporated in the paper below.



Figure-5 Graph for training & validation loss & accuracy

Classical algorithms in Machine Learning like naïve bayes, support vector machine (SVM), decision tree, linear regression, random forest etc. are used for comparing the results. These algorithms are commonly known for their hand crafted features. Accuracy in different algorithms would be computed by using the formula:

$$\frac{TP + TN}{TP + TN + FP + FN}$$

Where TP stands for True positive; TN stands for True negative; FP stands for False positive; FN stands for False negative.

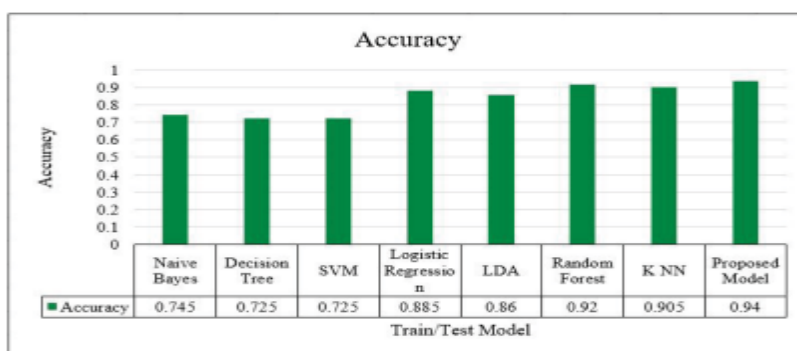


Figure-6 Graph of Accuracy of different machine learning approaches

M-Net model that proposed by authors consist of four different features like Hu-moments, Harlick, HSV-histogram and LBP-histogram. Metrics like F1-Score, Cohen-Kappa, Accuracy, Specificity etc. are compared for the results obtained by the existing algorithm and proposed model. Formula for F1-Score comparison metrics is as follows:

$$F_1 = \frac{2 * Precision * Recall}{Precision + Recall}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

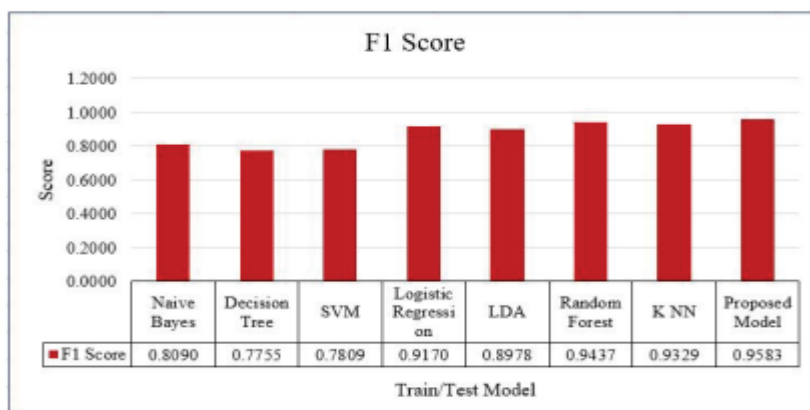


Figure-7 Graph of F1-Score comparison

The measurement of negative generation rate which is one of the performance measurement metrics for the new model is actually a proportion between true negative rate and actual negatives are known as specificity. Different algorithm comparison for performance metrics: specificity and Cohen-Kappa are represented in the figures-8 and 9 respectively

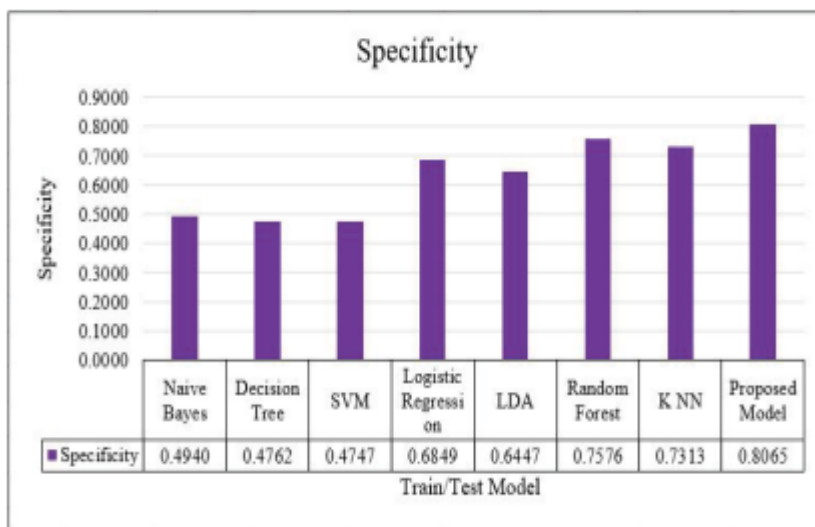


Figure-8 Graph of Specificity comparison

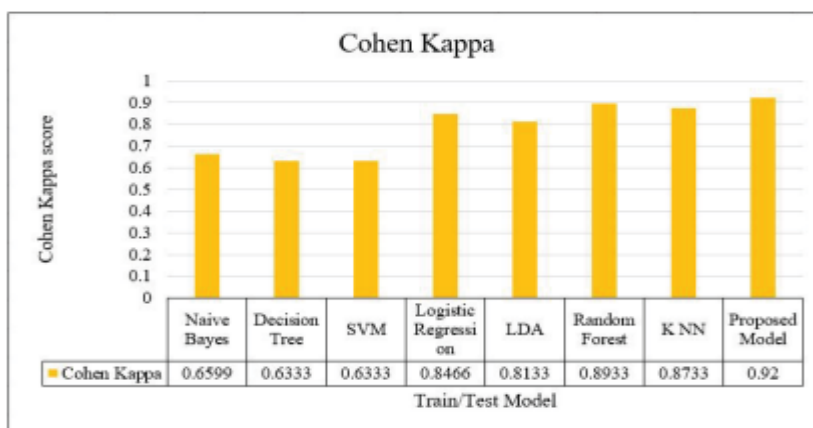


Figure-9 Graph of Cohen Kappa comparison

Area under the ROC-curve (AUC) is used to compare the performance of the various models and it is widely used due to

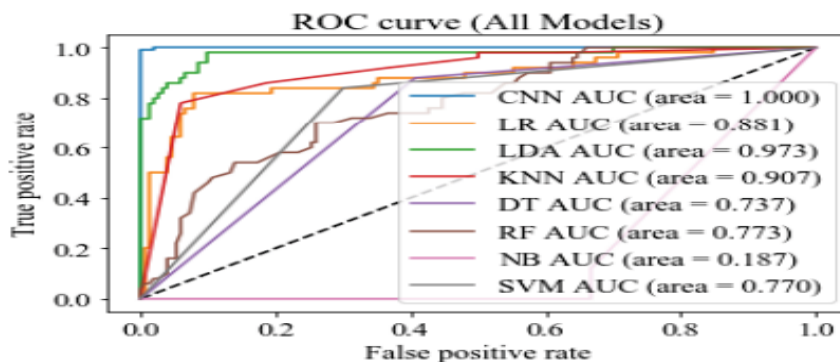


Figure-10 ROC curve with two features

scale-invariant and classification-threshold-invariant. ROC stands for receiver operating characteristic curve to plot the graph of different features for machine learning models based on various machine learning algorithms. ROC curve represents the performance of a model at different threshold values. When AUC combines with ROC they together are capable of classify the different classes present in a model. AUC-ROC curves represent the hand crafted features for various models along with proposed CNN based models. The curve representations with different features are displayed in the following figures.

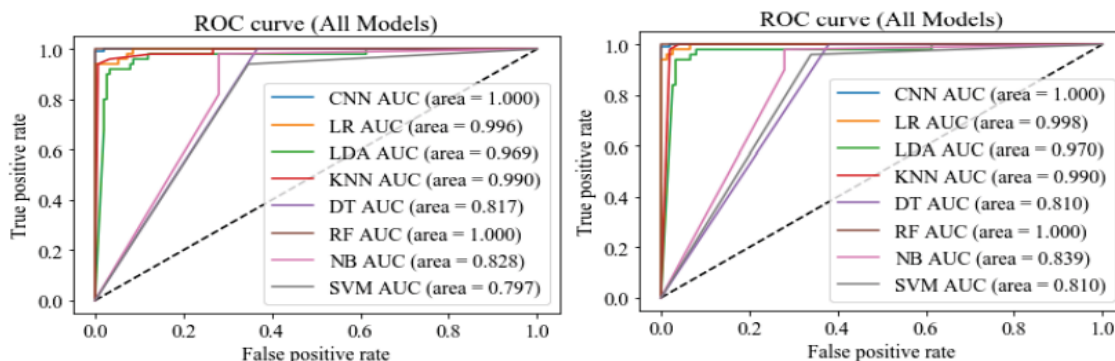


Figure-11 ROC curve with three & four features

Now we compare the proposed model based on CNN model with existing models like VGG16 and InceptionV3 for their performance. VGG16 is a CNN based pre-trained model and more accurate than the proposed model in certain areas but in the certain field of agriculture proposed model is better than the VGG16.

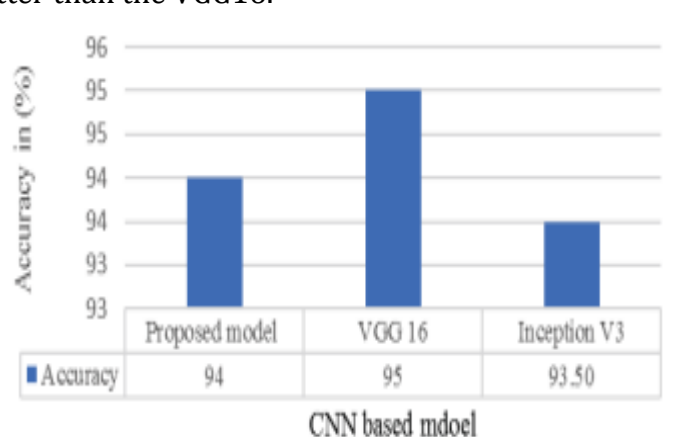


Figure-12 Comparison with pre-trained models

M-Net model based on deep learning using CNN as its base is more accurate than any other model belonging to this category on the given data set.

CONCLUSION

Crops are essential for living of human beings but there yield suffers from various crop diseases caused by micro-organisms. This not only impact the life of farmer but it also causes dent on lives of other human beings and domestic animals. But this can be cured by implementing the systems that uses modern information technology techniques like machine and deep learning models. These models have the ability to identify the disease in crops and prescribe their cure precisely. These models not only increase the quality and quantity of crop yields but also reduce the cost incurred in farming. Not one model is suitable for all the crops and it was not feasible to design the model for each crop. Due to the large number of crops and dataset required by Machine and deep learning model is not available. Author chooses to design the new model based on deep learning framework and generalize it, so that it become suitable for other crops having similar features. Models having generalization property are more suitable to the requirements of farmer. M-Net model could be generalized further to deal with corn crop with increased efficiency and accuracy. An application framework for the model should be designed to provide farmers interface in their native language. Learning from the model should be implemented on other crops which may have the similar features. Model should be proposed for the less known crops or having least similarity. Researchers or scientist should also consider the environmental factors and soil type before describing the solution.

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