RESEARCH ARTICLE Bhartiya Krishi Anusandhan Patrika, Volume 37 Issue 2: 173-177 (June 2022)

A Transfer Learning Approach for Leaf Image based Classification of Healthy and Diseased Leaves

Nilakshi Devi, Shakuntala Laskar

10.18805/BKAP467

ABSTRACT

Background: India is mainly an agriculturist country where agriculture is a very important sector for Indian economy. Different varieties of crops are grown in huge acres of land yielding sufficient quantity. But due to frequent attacks of pests and pathogens the plants gets infected and develops different diseases. These diseases affect the quality of crop production and put the consumer's health at risk. Thus, it is important to keep a track on the health of the plants on a regular basis so that required action can be taken without wasting any time. Therefore the study aimed to propose a method for automatic classification of healthy and diseased plant leaves using transfer learning approach.

Methods: Deep learning is gaining popularity among researchers due to its several advantages. Two approaches were used in deep learning: one is to build a model from scratch and the other to use pre-trained models (PTMs). This concept is known as transfer learning. It is based on the concept where the network learns from existing models and uses the knowledge to solve a completely different problem. These models are trained on huge datasets to solve a task that is similar to our desired problem. Mobile Net V2 has been used for our research problem and the beans dataset which is a publicly available dataset.

Result: Mobile Net V2 is a very light weight model which is trained on more than 1.4 M images. We have downloaded the pre-trained model and fine tuned the last layer to solve our desired task. The results observed that in just only 30 epochs our proposed model could achieve a classification accuracy of 98%. Also, we have compared our proposed method with other existing methods in literature and found that our proposed method had higher classification accuracy than other existing methods.

Key words: Agriculture, Machine learning, MobileNetV2, Pre-trained models, Transfer learning.

INTRODUCTION

Agriculture is a major sector in our Indian economy and more than half of the population depends on agriculture as their basic source of income. This sector contributes around 18% of the total GDP and over 60 per cent of the living population in India is engaged in agriculture (Agriculture Report 2022). Thus, agriculture indeed plays a vital role in Indian economy. According to a recent report, India ranks 2nd in the world in agriculture production and globally 9th for the agricultural export (state of agriculture in india-analytical reports 2022). In analytical reports of the state of agriculture in india, (2022) the Associated Chambers of Commerce and Industry of India, gave a statement that, the annual crop losses due to pests and diseases amounts to Rs.50,000 crore ($500 billion), which is significant in a country where the population is 1.3 billion. Further, with an estimated 9.9 billion global human population, expected by 2050 with food demand projected to leap 35%-56% in that time, farmers need to obtain maximum yield from the crops to meet the ever increasing food demand. But, there still exist a lot of challenges in Indian agriculture due to which the crop yield production gets disturbed, and one of the major causes of it is the plant diseases. In simple words we can say, a plant becomes diseased when it is continuously attacked by pathogens and pests that results in an abnormal process that disturbs the plant's normal growth, function and other activities. Frequent attack of pathogenic organisms like bacteria, virus, fungi *etc.* and other environmental conditions causes severe crop damage leading to poor yield which affects the farmers a lot.

Thus, it is important that the farmers should be provided with the latest of technologies to boost crop production as crop disease poses a major threat to food security and leads to insufficient food production. Fig 1 shows the estimated crop losses due to plant disease Oreke *et al*, (2004).

One of the important actions to be taken to boost crop production is to check for any disease of the plants on a regular basis. In modern world, artificial intelligence has played a major role in solving many real life problems. AI had its great impact in major sectors like self driving cars, health care, speech recognition as described by Aamir Ahmad *et al.*, (2019). Thus, AI can also be used as a beneficial tool for regular monitoring of the leaves through image based disease detection. Different machine learning

Department of Electrical and Electronics Engineering, Assam Don Bosco University, Azara-781 017, Assam, India.

Corresponding Author: Nilakshi Devi, Department of Electrical and Electronics Engineering, Assam Don Bosco University, Azara-781 017, Assam, India. Email: nilakshidevi4@gmail.com

How to cite this article: Devi, N. and Laskar, S. (2022). A Transfer Learning Approach for Leaf Image based Classification of Healthy and Diseased Leaves. Bhartiya Krishi Anusandhan Patrika. 37(2): 173-177. DOI: 10.18805/BKAP467.

Submitted: 21-02-2022 **Accepted:** 03-06-2022 **Online:** 20-06-2022

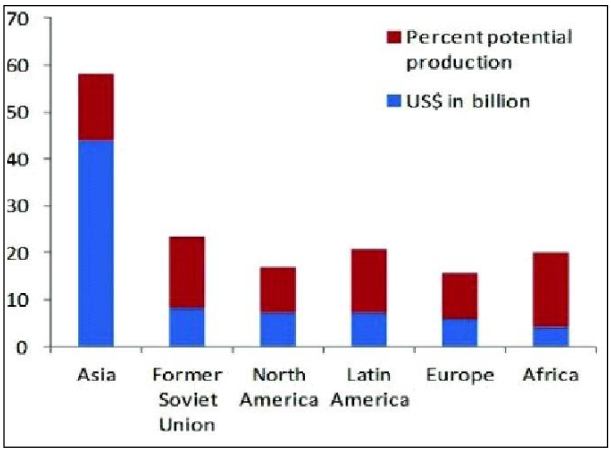

Fig 1: Continent wise crop loss in1988-90.

algorithms have been developed by the researchers all over the globe to detect plant disease via leaf images. Over the years many researchers have proposed different methods for detection of plant diseases which were efficient to a certain extent. Many learning models have been proposed in literature (Wang *et al.,* 2018; Zhang *et al.,* 2019) to classify different diseases in tomato, cassava, cucumber *etc.*

A classification approach to detect maize leaf disease was developed by Malusi *et al.*, (2019) and the authors claimed that their proposed model could detect three different types of maize disease from healthy leaves efficiently.

Cheng *et al.*, (2019) have developed a tea leaf disease detection method using LeafNet model. The authors found that the LeafNet algorithm was superior in disease identification task compared to other machine learning models.

Durmus *et al.,* (2017) developed a tomato leaf disease detection method using AlexNet and SqueezeNet models and the authors claimed that their model could successfully detect the disease class from the healthy class of tomato leaves.

Sun *et al.,* (2019) proposed a cucumber leaf disease detection method using DCNN (Deep Convolution Neural Network) and the results were compared with other existing ML models. The authors found their proposed system was more efficient than other traditional models.

These algorithms were successful to some extent but traditional machine learning algorithms have the greatest disadvantage of manual feature extraction which makes the entire process time consuming and laborious. To overcome this limitation, researchers started utilizing deep learning algorithms which eliminate the manual process of feature extraction and the network extracts the features by itself while on training. There are two approaches of deep learning. The first approach is to build an entire model from scratch and second method is to apply transfer learning using PTMs. In our paper we have utilized the second approach for classification of healthy and diseased plant leaves. Transfer learning can be stated as a process where the knowledge gained from solving one task is stored in the network to solve other problem. Transfer Learning can be implemented efficiently using PTMs. A pre-trained model can be defined as a model designed by others to decipher problems of similar domain as described by Ning Dai *et al.,* (2020).

MATERIALS AND METHODS

This work was carried out at Assam Don Bosco University from July 2021- January 2022. Traditional ML algorithms require the need of feature extraction which is a very tedious process, thus to overcome this limitation the concept of transfer learning have been explored. In transfer learning the biggest advantage is that we do not need to manually extract features from the image as the network learns it by itself. Moreover to create a deep learning model from scratch requires a lot of data which becomes difficult sometimes to obtain. In such cases, transfer learning offer better possibilities to train the neural network with the help of PTMs.

In this paper, we have utilized the concept of transfer learning in disease classification, we have downloaded a pre-trained model and fine-tuned the last layer according to our requirements. We have used Mobile NetV2 model which is trained previously on the ImageNet that consist of 1.4 million images of different categories. We have used this model as our base model to train with our dataset and classify the diseased and healthy leaf images. Fig 2 shows the convolutional blocks of Mobile Net V2.

MobileNetV2 has arrangement like inverted residual structure, is a light weight model, much suitable for mobile applications. The architecture consists of two blocks, one block is used as the residual block and the second block for downsizing with each block comprising of three layers. The first layer is the 1*1 convolution with rectified linear unit, the second layer is the depthwise convolution layer, the third layer is the 1*1 convolution layer eliminating non-linearity. Fig 3 depicts the overall architecture of MobileNet V2.

We have used TensorFlow and Keras for developing and training our network. A free and open-source software library for developing machine learning and deep learning models on a high level, TensorFlow and Keras provides the best platform to develop AI models, as stated by Aurelien Geron *et al.* (2019).

In this paper, we have downloaded the “Beans” from the tensorflow datasets, which is a dataset consisting of images of beans taken in real field using smartphone cameras. The dataset consist of three classes where there are, two disease class namely angular leaf spot and bean rust and one healthy class of bean leaves. Fig 4 depicts the “beans” dataset.

The dataset have been split into three parts: ‘test’, ‘train’ and ‘validation’ and each part consist of 128, 1034 and 133 images respectively. Taking advantage of the Keras platform, we utilized the concept of transfer learning in deciphering our classification task. As described by Aurelien Geron *et al.* (2019), layers and models are the core data structures of the keras.

Fine tuning

Fine tuning can be described as the best approach to transfer learning where the model output can be changed

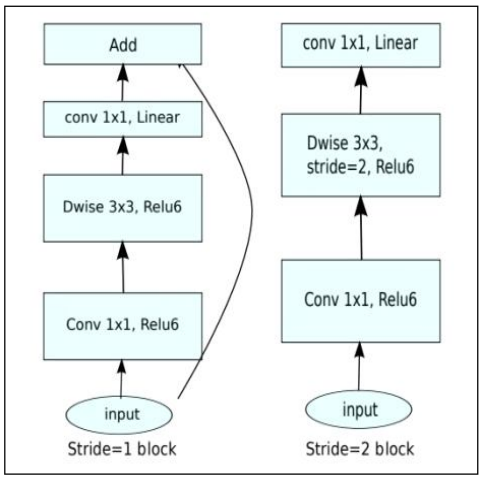

Fig 2: Convolutional blocks of MobileNet V2.

Input	Operator	t	c	n	s
$224^2 \times 3$	conv2d	-	32	1	2
$112^2 \times 32$	bottleneck	1	16	1	1
$112^2 \times 16$	bottleneck	6	24	2	2
$56^2 \times 24$	bottleneck	6	32	3	2
$28^2 \times 32$	bottleneck	6	64	4	2
$14^2 \times 64$	bottleneck	6	96	3	1
$14^2 \times 96$	bottleneck	6	160	3	2
$7^2 \times 160$	bottleneck	6	320	1	1
$7^2 \times 320$	conv2d 1x1	-	1280	1	1
$7^2 \times 1280$	avgpool 7x7	-	-	1	-
$1 \times 1 \times 1280$	conv2d 1x1	-	k	-	

Fig 3: Overall architecture of MobileNet V2.
Where 't' is the expansion factor, 'c' denotes the number of output channels, 'n' stands for repeating number, s denotes stride.

to fit our desired task and train only the output model as mentioned by Eli Stevens *et al*., (2020). Fine tuning can be described as the process of training a neural network on our desired dataset using the pre-trained weights obtained from training the network on another dataset, but similar of its kind. Fine tuning helps in obtaining more accurate results also speeds up the training process, as mentioned by Eli Stevens *et al.,* (2020).

RESULTS AND DISCUSSION

The "Beans" dataset was used which is publicly available in the Tensorflow hub. MobileNet V2 pre-trained model was used and fine tuning was performed on the last layer. The training and validation datasets consist of 1034 and 133 images respectively and our testing dataset consist of 128 images. We have used Keras for constructing our deep learning model. Keras is a powerful platform for developing and evaluating deep learning models. We have created a kera sequential layer, with dropout rate as 30% and then added a final dense layer to it with three classes and have used 'softmax' activation. While compiling the model we have used 'Adam Optimizer', with Categorical Crossentropy as the loss function. In simple words, a sequential model can be described as a linear stack of layers, stated by Aurelien Geron *et al.,* (2019). In an artificial neural network, the activation function plays a very important role as it plays a crucial part in the learning process. It can be defined as the function that helps the network in gaining knowledge of the complex patterns present in the data. Optimization is another criterion of a efficient deep learning model. The optimizer used here is the Adam optimizer which is the best optimizer since it can provide optimal solutions. As described by, Francois Chollet *et al.,* (2017), Adam is the best optimizer that can be used because it combines the excellent

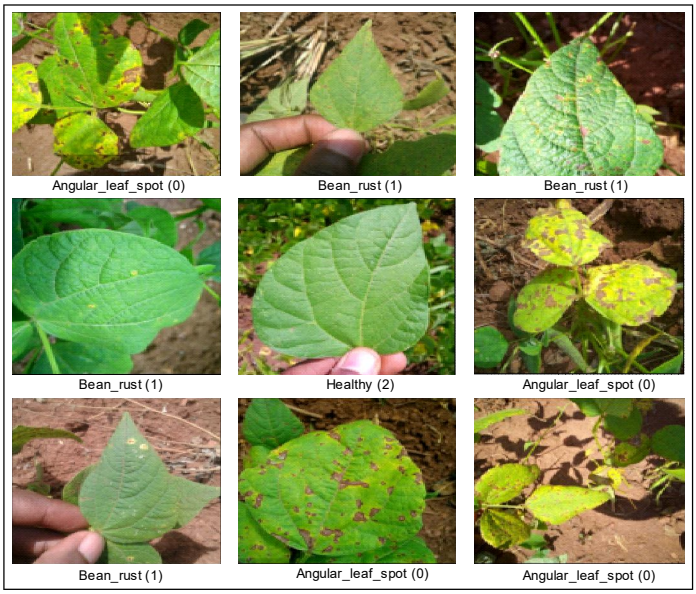

Fig 4: A few images of the beans data set.

properties of the AdaGrad and RMSProp algorithms to provide an optimization algorithm that can handle sparse gradients on noisy problems. Categorical crossentropy is used here as a loss function because it suits best in multi-class classification tasks. On training the neural network we obtained a classification accuracy of 98% in just only 30 epochs with minimal loss. Fig 5 shows the classification accuracy of the model and Fig 6 depicts the model loss.

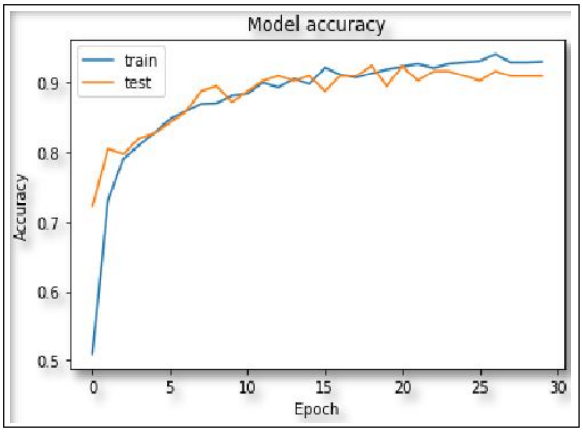

Fig 5: Classification accuracy of our proposed method.

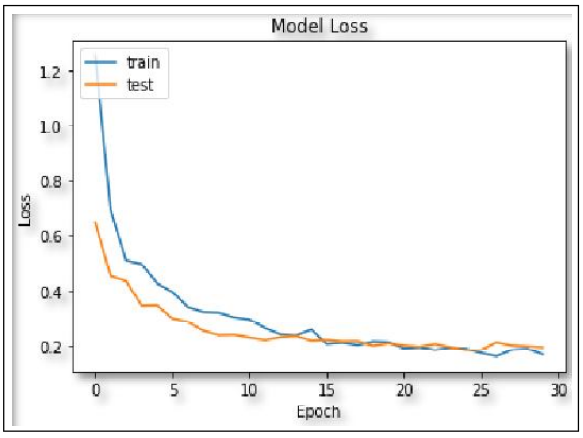

Fig 6: Model Loss of our proposed method.

The confusion matrix obtained through our proposed method is shown in Fig 7.

There are a total of 128 images in our "test" set consisting of 43 angular spot leaf images, 43 bean rust images and 42 healthy leaf images. From the confusion matrix, we can observe that in the first category consisting of 43 angular spot leaf images, our proposed method could classify 40 images correctly with only three wrong classifications, again in the second category consisting of 43 bean rust images, 36 images were classified correctly by the system with only seven wrong classifications and finally in the third category consisting of 42 healthy leaf images, 40 images were classified correctly with just two wrong classifications. Thus, we can conclude that our proposed method was able to classify the diseased and the healthy leaf images efficiently. Indeed our proposed method would be beneficial in regular monitoring of the leaves.

To study the efficiency of our method we compared our proposed model with other existing methods in literature and found that our system yield better results. The results are summarized in Table 1.

Table 1: A comparison of training accuracy of our proposed method with other existing methods in literature in classification of healthy and diseased leaves.

Model	Training accuracy
2D-CNN-BiDGRU (Wang *et al.* 2018	74%
Inception V3 (Ramcharan *et al.* 2017)	93%
CNN (Fujita *et al.* 2016)	82.31%
CNN (Sibiya *et al.* 2019)	93%
VGG-A, CNN (Kwak *et al.* 2017)	93%
(Our Proposed Method)	
MobileNet V2	98%

From the above table, we can observe that our proposed method showed better training accuracy in comparison with other methods.

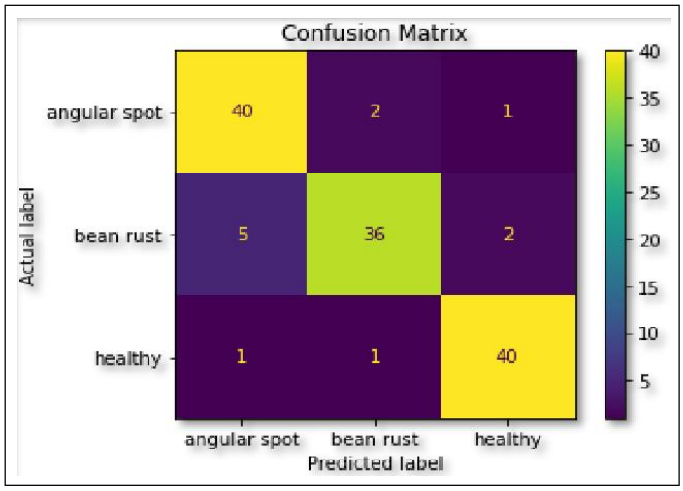

Fig 7: Confusion matrix obtained.

CONCLUSION

Frequent attack of the pest and pathogens disturbs the normal functions of the plant and thus, the plant starts developing diseases. Plant disease detection poses a major threat to agricultural production and food security. Thus, it is important that the farmers need to be well equipped with the latest technologies for boosting agriculture production. AI technology has been successfully applied in different sectors like health care, self driving cars, speech processing *etc.* The ability of AI to perceive the problems, understand and analyze those providing optimal solutions has given an opportunity to AI to prove its ability in addressing the agriculture concerns also. AI can offer its multiple advantages in diagnosing plant disease, detecting weeds, in crop harvesting, monitoring plants health *etc.* Thus, farmers have to take help of artificial intelligence in addressing the critical problems of agriculture. Though machine learning models have occupied much of the space of artificial intelligence, yet due to its laborious and time consuming methods to train the neural networks, deep learning is gaining much attention with respect to transfer learning. Applying the process of transfer learning with the help of PTMs has indeed could grab the attention of smart researchers.

ResNet152 is a neural network consisting of 152 layers and it employs the technique of residual mapping. One of the greatest advantage of using ResNet 152 is that the training error reduces with the increase in number of layers. In our paper we achieved a training accuracy of 98% with a minimal model loss. The confusion matrix obtained also justifies that our proposed method will indeed be helpful in monitoring the health of the plants on a regular basis, so that required action can be taken if the plants are found to be affected by any disease.

REFERENCES

Aamir, A., Malik, H. (2019). Applications of Artificial Intelligence Techniques in Engineering, Advance in Intelligent Systems and Computing. 20(1): 698. https://doi.org/10.1007/978-981-13-1819-1_5.

Aurelin, G. (2019). Hands-on Machine Learning with Scikit-Learn, Keras and Tensor Flow, O'Reilly Publisher.

Britannica Encyclopedia on Plant Disease. https://www.britannica.com/plant disease (last checked on Jan 21/2022).

Chen, Gao, Liu. (2019). Visual tea leaf disease recognition using a convolutional neural network model. Symmetry. 11(2): 343-350.

Dekne, Oreke, Schonbeck. (2004). Crop Production and Crop Protection. Elsevier Science Publisher.

Durmu (2017). Disease detection on the leaves of the tomato plants by using deep learning. Proceedings of the 2017 6th International Conference on Agro-Geoinformatics.

Dang, Hassan, Kwak. (2017). Deep convolutional neural network for classifying Fusarium wilt of radish from unmanned aerial vehicles. Journal of Appl. Remote Sens. 11(3): 426-432.

Eli, S., Luca, A., Thomas, V. (2020). Deep Learning with Pytorch. Manning Publishers.

Francois, C. *et al.* (2017). Deep Learning with Phyton. Manning Publishers.

Fujita, Kagiwada, Iyatomi. (2016). Basic Investigation on a Robust and Practical Plant Diagnostic System. In Proceedings of the 2016 15th IEEE International Conference on Machine Learning and Applications (ICMLA). 989-992.

Jin, W. (2018). Classifying wheat hyperspectral pixels of healthy heads and Fusarium head blight disease using a deep neural network in the wild field. Remote Sensors. 10(1): 395-420.

Ramcharan, M. (2017). Deep learning for image-based cassava disease detection. Front. Plant Sci. 8(2): 1852.

Sibiya, M., Sumbwanyambe. (2019). Computational procedure for the recognition and classification of maize leaf diseases out of healthy leaves using convolutional neural networks. AgriEngineerin. 30(4): 119-131.

State of Agriculture in India-Analytical Reports. https://prsindia.org/policy/analytical-reports/state-agriculture-india (last checked on Jan 21/2022).

Sun, Z. (2019). A recognition method for cucumber diseases using leaf symptom images based on deep convolutional neural network. Computers and Electronics in Agriculture. 20(3). 94-100.

TianXiang, S., Dai, N., Qiu, XiP. (2020). Pre-trained models for natural language processing: A survey. Science China Technological Sciences. 63(1): 1872-1897.