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Automatic Classification of Medicinal Plants Using State-Of-The-Art Pre-Trained Neural Networks

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Abstract

Now a days every mankind is suffering due to infections. Ayurveda, the science of life helped to take preventive measures which boost our immunity. It is plant-based science. Many medicinal plants found useful in daily life of common people for boosting immunity. Identifying the plant species having medicinal plant is challenging, it requires botanical expert. In the process of manual identification, botanical experts use various plant features as the identification keys, which are examined adaptively and progressively to identify plant species. The shortage of experts and trained taxonomist created global taxonomic impediment problem which is one of the major challenges. Various researchers have worked in the field of automatic classification of plants since the last decade. The leaf is considered as primary input as it is available throughout the whole year. The research paper mainly focuses on the study of transfer learning approach for medicinal plant classification, which reuse already developed model at the starting point for model on a second task. Transfer learning approach is a black box approach used for image classification and many more applications by extracting features from an image. Some of the transfer learning models are MobileNet-V1, VGG-19, ResNet-50, VGG-16. Here it uses Mendeley

	dataset of Indian medicinal plant species which is freely available. Output layer classifies the species of leaves. The result provides evaluation and variations of above listed features extracted models. MobileNetV1 achieves maximum accuracy of 98%. ***Keyword: Automated Classification, medicinal plants, machine learning, Transfer learning, Pretrained CNN models, VGG-16, VGG-19, MobileNet V1 and MobileNet V2.***

1. Introduction

Plant extracts are involved in the use of traditional medicines which implies that around 3.5-4 billion humans rely over plants as their drug resource. Biodiversity on earth is represented by the large use of medicines by plant resources[1]. As some species of plants are used for food, various species of plants. In the current era of pandemic medicinal plant species like citrus spp, allium sativum, allium cepa found effective in management of infections. Researchers are vigorously involved to screen plants for their role in discovering new drugs in the area of traditional medicines [2].

University of Banaras was the first school to teach Ayurvedic medicine in 500 BC where the Samhita (or encyclopedia of medicine) was written. Ayurveda is thereby the first of all medicinal traditions. It is even older than the Chinese medicine and is the originator of systemized medicine culture. Ayurveda is holistic and practical approach to establish harmony and balance by set of Rules to live by. Discords think to have taken many of his ideas from India. India is famous for in the area of ethnopharmacology and traditional medicine. India traditional medicine formulations use multiple components of mixtures which have therapeutic use based upon empirical understanding than mechanistic knowledge of constituents in the mixture. Up till now understanding of Indian traditional medicine, counting all major medicinal plants and formulations had been buried into books like INDIAN MATERIA and AYURVEDA MATRIA MEDICA. As these books are non-digital, their efficient use is limited for the new discoveries.

In the process of identification botanist manually use diverse plant features as identification metrics, which then used to examine adaptively and sequentially to classify species. In core, a handler of an identification metric is responding to the train of doubts about different features of an unclassified plant (e.g., color, number of petals, shape, presence of hairs and thorns) constantly aiming on the greatest discerning attributes and tightening down the collection of contender genus. This train of response doubts leads to the prediction of species. Though, the characterization of plant genus from field examination involves a considerable botanical skill, which sets it past the vicinity of maximum environment enthusiasts. Traditional plant species classification is nearly impossible for the common society and demanding enough for specialists [16].

In instance of machine learning, models are developed for precise requirement, but in transfer learning already established model for specific task is reprocessed for various but associated task. Although previous model had been focused on immense amount of data, it is reused on fewer data.

Using transfer learning method, we output enhanced performance with fewer resource utilization. The usual classification tactic is shown in
Figure *1* .

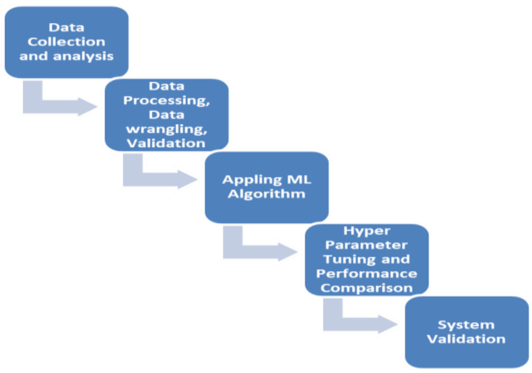

Figure 1: General Classification approach [3]

Various researchers used the general classification approach (Figure *1*) for automatic classification of plant species. Once done the data collection and preprocessing, the feature extraction is carried out. For feature extraction leaf is considered as a substantial source of information .It has different features which can be categorized as global features and local features .Shape ,color, texture are local/ basic features. The comprehensive attributes are characteristics that describe a leaf shape in broad, like width, length and leaf section. There are various feature extraction methods applied by researchers considering leaf as an input [17].

The objective of this research paper is use of pretrained models to extract meaningful information from pre-processed data. In feature extraction, we begin by a pre-trained model and only revise the last layer weights from which we obtain forecasts. This is called feature extraction as the pre-trained CNN is used as a constant feature-extractor and one change is the output layer.

The research paper focuses on the study of transfer learning approach for medicinal plant classification, which reuse already developed model at the starting point for model on a second task [4]. The main focus is on Leaf image as input. Section II focuses on the various machine learning methods for automated Identification of medicinal leaves. Section III summarizes various pretrained architectures for image classification. section IV gives experimentation evaluation and analysis using transfer learning approach. Section V concludes the paper.

2. The Various Current State of Art Techniques for Automatic Identification of Medicinal Plants

Various machine learning approaches are used to automatically classify medicinal plants. In [3] author have done automatic taxon identification of medicinal plants. A system called as LeafNet has developed using the datasets Flavia, leaf snap and foliage. LeafNet opted CNN method for identification process. This system has better performance when compared with manual system of plant identification. In this[5] the author has done detailed review of various machine learning techniques taking leaf image as a input. In this paper review of various locally available datasets has been done. Commonly available feature extraction methods are also elaborated. Various available classifiers and their accuracy with available local dataset is discussed. In this paper author has proposed Ayur leaf process [6]. The dataset has 40 Medicinal plant leaf images. For classification SVM classifier is used. Model Achieves 96% accuracy. In this author calculated curvature complexity. Using Curvature scale space, the identification is carried out. The formula for parameterized curvature is as follows:

$$c(z) = \frac{a^1(z)b^2(z)-a^2(z)b^{1(z)}}{(a^1(z)^2+b^1\ z^2)^{3/2}} \text{------------------- equation 1} \qquad [7]$$

The method gives better performance when compared with traditional method of shape analysis. In research [8] author used histogram of oriented gradient features for identification of Plant species. Swedish and Flavia datasets is used for experimentation. CNN model with RELU activation function is used. The results are better as compared to other methods.

Amgad Muneer in his research [9] study proposed a system which uses two classifiers SVM and DLNN. SVM attained 74.63% classification accuracy, and DLNN attained 93% classification accuracy but DLNN approach take more time complexity. Medicinal plants from Malaysia are used for experimentation.

Jana and Patrick in their Review on plant species identification applying computer vision [10] has studied 120 papers of last decade. Comparative study of various researchers by considering different elements as a feature extractor, classifiers, different datasets, and different implementation platforms are used for analysis. Kunlong Yang and et al [11] in his research paper carried out classification of plant species with complex background leaf images. Mask –R – CNN is used for leaf segmentation.

3. Pretrained models for image classification:

Convolutional Neural network is widely used for various image processing applications. For Human Being it is easy to identify and distinguish images. But for Machine, It is difficult to identify and distinguish the images, Computer vision works similar to human brain. Pretrained model supports reusability feature. It can be reused in two different ways, pretrained model as a feature extractor and tuning the pretrained model. Pretrained models found effective for image detection task. The pretrained models already give you architecture, so they are easy to use. With less required time they give us better outputs. Here we discuss four different pretrained models which are used for experimentation, VGG16, VGG-19, MobileNet V1 and MobileNet V2.

3.1 Deep Convolutional Neural Networks for Image Recognition. (VGG-16):

VGG-16- This model is trained on ImageNet dataset. Model Found a good feature extractor. It is 16-layer model built using ImageNet dataset. This is widely used for image Identification and classification. Karen Simonyan∗ & Andrew Zisserman [10] in their research paper explained detail architecture of VGG-16. The input to any of the network formations is fixed to be a static size 224 x 224 image with color channels as – RGB. The one pre-processing accomplished is normalizing the RGB estimates in support of each pixel. This is accomplished by subtracting the mean from each pixel.
Image is delivered over the initial pile of 2 convolution layers of the very tiny receptive magnitude of 3 x 3, after that ReLU activation functions. Each of the two layers include 64 filters. The convolution step is stable at 1 pixel, and the padding is also a pixel. This formation preserves the dimensional outcome, and the magnitude of the last activation map is the identical as the first image dimensions. Activation maps are further delivered through spatial maximum pooling on a 2 x 2-pixel window, by a step of 2 pixels. This halves dimension of the activations. Thus, the magnitude of the activations at the bottom of the opening stack is 112 x 112 x 64.
Activations further flow ahead on a identical second pile, now with 128 filters as beside 64 in the initial one. Subsequently, the size later the following stack turn into 56 x 56 x 128. Followed by the third pile with three layers and a maximum pool layer. The number of filters used are 256, producing the output dimensions of the stack as 28 x 28 x 256. Then followed by 2 stacks of 3 layers, with every layer comprising 512 filters. The output at the bottom of both these piles is 7 x 7 x 512.
The piles of CNN layers are trailed by 3 completely connected layers along a flattening layer in the middle. The initial 2 have 4,096 neurons, and the last completely connected layer provides as the final layer and has a thousand neurons equivalent to the 1,000 potential classes for the ImageNet data. The final layer is then followed by the Softmax activation function layer applied for categorization.

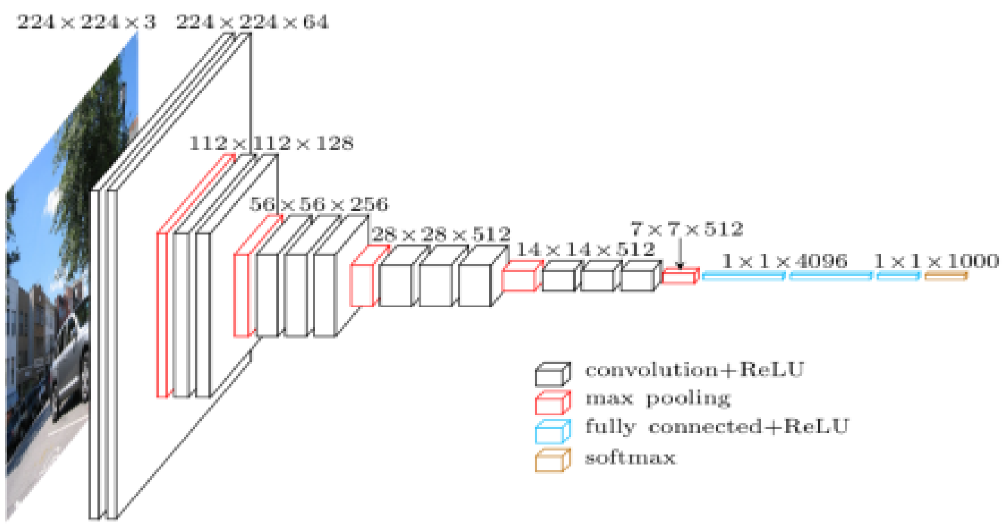

Figure 2: VGG16 architecture[12]

3.2 VGG-19:

It is a variation of VGG architecture. It is a CNN which is 19 layers long. We can upload a pretrained form of the model trained on greater than 1 million images by the ImageNet data. This pretrained model classifies images into thousand class categories, like pencil, keyboard, mouse, and numerous animals.

As outcome, the model has learned great feature interpretations for a broad collection of images. The model has input image dimension of 224-by-224.

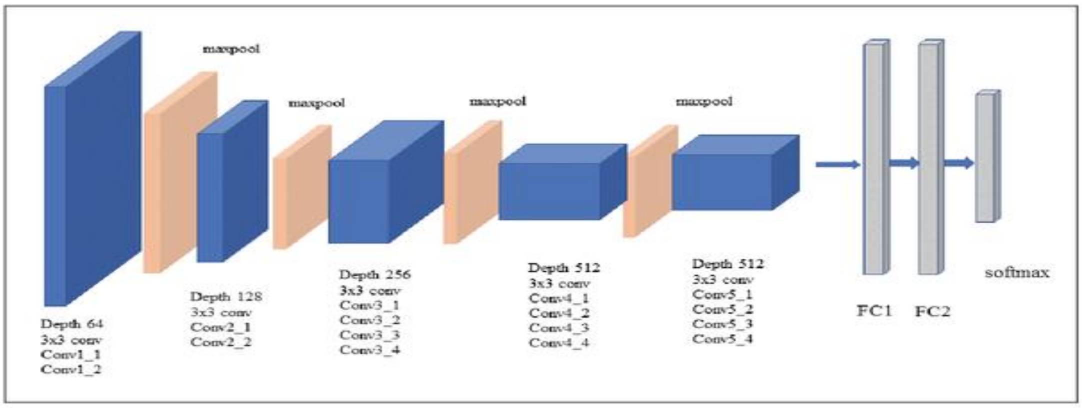

Figure 3: VGG19 architecture[12]

• Image input dimension for this model is (224 x 224) implies that the matrix is of the shape (224,224,3).
• Only preprocessing that was conducted is, they subtracted the mean of RGB magnitude from every pixel, computed on the entire training dataset.
• Use of kernels of size (3 * 3) with a step dimension of a pixel, this allowed them to reach the entire idea of the image.
• Spatial padding was utilized to maintain the spatial dimension of the image.
• Max pooling was conducted on 2 x 2-pixel windows with step size of 2.
• Followed by Rectified linear unit (ReLu) to lead non-linearity to type the model output better and to reduce computation time as the earlier models used TAN-H and SIGMOID functions, thereby this evidenced pretty better than the above.
• Employed 3 completely connected layers by which the initial 2 were of magnitude 4096 and after, a layer with a thousand channels aimed at 1000-way ILSVRC classification and the last layer had soft max activation function.

3.3 MobileNet V1:

It's architecture mainly emphases on light weight deep NN on mobile app and further implanted apps. Howard & et al in their research [13] described how this architecture works. It mainly uses depth wise distinct convolutions to build lighter models. MobileNet is an effective and convenient Convolution Neural Net architecture which is implemented in actual realm products. MobileNet chiefly use depth wise distinct convolutions instead of the standard convolutions implemented in earlier designs to shape lighter models. They introduce 2 new universal hyperparameters (resolution and width multiplier) that allowed the model creators to trade off accuracy or latency for speediness and small size depending on their necessities.

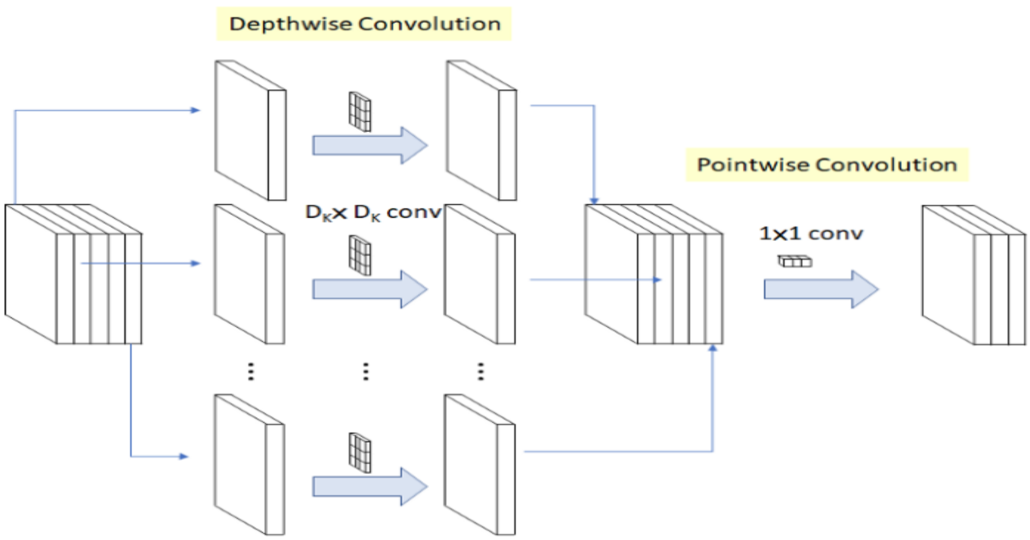

Figure 4: MobileNet V1 architecture [14]

3.4 MobileNet V2:

Few substantial deviations were done to the MobileNetV1 design which resulted in a substantial growth in the accuracy of the pre-trained model. The key changes done to the design were the arrival of inverted residual blocks followed by linear bottlenecks and the usage of the ReLU6 function \

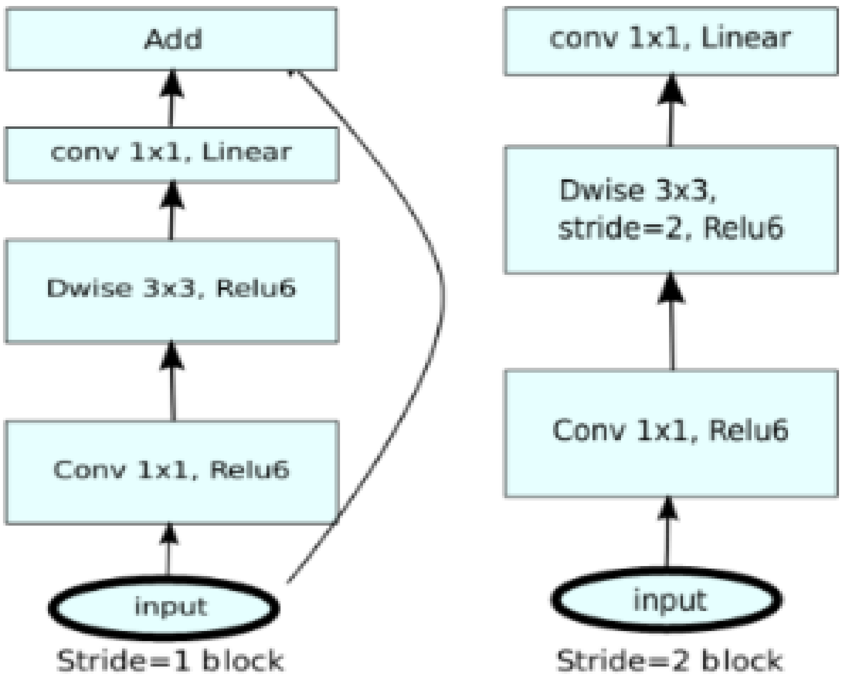

Figure 5: MobileNet V2 architecture[14]

This deep neural network architecture is useful for mobile apps and limited resource environment. Comparison of mobileNetV1 and mobileNet V2. Comparison of MobileNetV1 and MobilenetV2 is as shown in table1 below.

Table 1 Comparison between MobileNetV1 and MobileNetV2

Version	MAC	Parameters
MobileNet-V1	569 million	4.24 million
MobileNet-V2	300 million	3.47 million

4. Proposed System Design:

The experiment is to classify images into 26 classes from Indian Medicinal Leaves Dataset using different transfer learning models. For the purpose of experimentation, dataset was augmented. The pre-trained models namely VGG-19, VGG-16, MobileNet V2 and MobileNet V1 had been trained, implementing the state-of-art algorithms, on the ImageNet data that comprises of 1000 categories of images. Rather than employing the hand-made feature extractors, we made use of the above pre-trained models for the similar intent. Accuracy is applied as the valuation metric shown in Equation 2.

$$\text{Accuracy} = \frac{\text{Correct test set predictions}}{\text{Total No of Test set predictions}} \quad \text{--------------Eq 2}$$

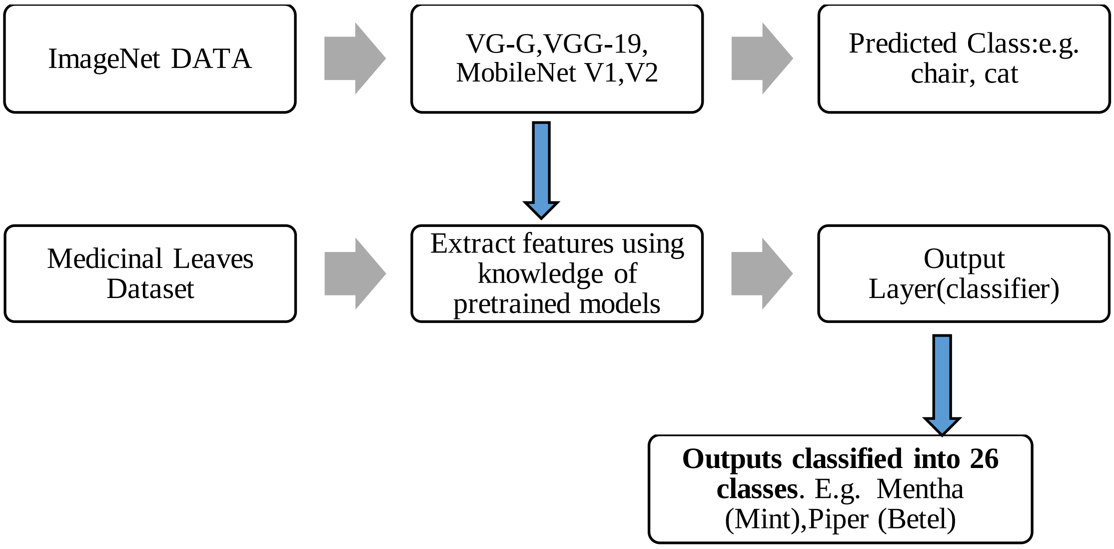

Figure 6: Proposed System Design

4.1. Datasets:

The datasets used in this paper are Indian Medicinal leaves dataset consisting of 26 classes. Only whole images were used. Training set images from all datasets were augmented by applying shear range of 20% and zoom range 20%, translating the images horizontally. As it has been seen in the previous works that CNNs learn better with a greater number of examples and the number of images in some classes of leaves were fairly less. One sample image from each dataset is shown in Figure 7.

(A) (B) (C)

Figure 7:(A) Alpinia Galanga (Rasna) (B) Murraya Koenigii (Curry) (C) Ocimum Tenuiflorum (Tulsi)[15]

4.2. Transfer learning for the feature extraction

Attribute set achieved from leaves images can be built on texture, shape, venation or color. Above features can also be utilized in blend. Here, we introduce a contrast of feature extraction facilities of four pre-trained CNNs. Transfer learning is the idea of using the understanding gained by the model using the state-of-art algorithm, to be functional for detection of other associated images. In this process it is demonstrated that the attributes gained from the pre-trained networks are effective in distinguishing other linked images. Feature extraction aids to restrict over-fitting of CNNs, accelerate training, enhance accuracy and enhance data visualization. It also lowers down the features from the data by making new features by the current ones and removing the initial ones. This procedure makes a brief of the unique features by the data. Attributes for our research were found from completely connected layer of the pre-trained CNNs. They are abridged in Table 1(Depth refers to the topologic deepness which contains batch normalization layers, actication layers etc).

Table 2: List of used pre-trained CNNs, Input image size, depth and no. of features extracted from every model.

Model name	**Input image size**	**Depth**	Trainable parameters
VGG-16	224x224	16	14,714,688
MobileNet-V2	224x224	50	2,225,153
VGG-19	224x224	19	20,024,384
MobileNet-V1	224x224	28	3,206,976

4.3. Experiments and Results

Many experiments were performed using various pre-trained CNNs on the mentioned data. The only ones which assisted to attain great results are shown in this section. The images were initially augmented and later resized agreeing to conditions of the feature extractor model which is employed. The dimension of feature vector for various models is revealed in Table 1. Feature vector was formerly flattened and delivered into to the final layer to classify image into one the 26 classes. For the aim of assessment, accuracy was used as the metric. The clarification of the datasets and relative analysis is given below.

4.4. Evaluation on dataset.

Medicinal leaves data was presented. It contains of 26 groups of leaves. An image from the data is displayed in Figure 3 (a). Images of the training dataset are augmented so the model can learn numerous features. The images are initially resized and pre-processed based upon the conditions of the feature picker and then categorized. Training is performed for 50 epochs, loss function used was categorical-cross-entropy, optimizer picked was 'adam' and accuracy as the tangible metric and the accuracies found on the test dataset are displayed in the Table 3:

Table 3: Accuracy achieved from every pre-trained model on Indian Medicinal Leaves Dataset.

CNN Model	Accuracy (in%)
VGG-16	97
MobileNet-V2	97
MobileNet-V1	98
VGG-19	96

5. Conclusion

The task of pre-trained models as the feature extractors was studied. MobileNet-V1 as a feature extractor surpassed rest CNN pre-trained model. MobileNet-V1 resolves the vanishing gradient problem faced in CNN as they develop deeper. They also have restricted layers, few parameters and allowed feature re-usage. In all the scenarios above, it can be strongly that the feature extracted by MobileNet-V1 followed in highest accuracy possible. It attained 98% accuracy upon Mendely Indian medicinal leaf data.

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