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Digital Dermatology

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Key words: Deep learning, classification, image processing, VGG16, support vector machine

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Abstract: Skin diseases are more common than other diseases. These diseases may be caused by fungal infection, bacteria, allergy or viruses, etc. Despite being common its diagnosis is extremely difficult because of its complexities of skin tone, color, presence of hair. Treatment options for each type of disease are varying depending on the prognosis of a disease. Traditional method of initial clinical screening requires a visual diagnosing by specialized expertise but the cost of dermatologist to monitor is very high. The advancement of lasers and Photonics based medical technology has made it possible to diagnose the skin diseases much more quickly and accurately. But the cost of such diagnosis is also still limited and very expensive. There are often infections in skin due to viscus damages, therefore it's necessary to spot these diseases as soon as possible. Thus, there is a need to develop an automated system of classification for the early diagnosis of severity of the disease and to prevent its spread. The proposed method is built on well-known convolutional neural network VGG16. The study focuses on improving the classification accuracy of skin disease diagnosing. The CNN Model is used to extract feature from the images and feature set is given as an input to machine learning algorithms like random forest, kNN and support vector machine. The simulation result for the classification of skin disease show the flexibility and effectiveness of the proposed system. However, SVM has achieved a higher classification accuracy of 98%.

INTRODUCTION

Dermatology is a branch of science that deals with skin and related disease. It deals with skin, hair, nail and its diseases. It is concerned with normal skin and diseases skin, its spread and its medicine. Cancers, cosmetic and aging conditions of the skin, fat, hair, nails and oral and genital membranes are all aspects of dermatology. Skin is the largest organ in the human body and it is mainly concerned in the dermatology. Dermatologist is an expert in the dermatology field[1]. A dermatologist has the specialization in medical or surgical treatment. Being the largest organ it is helpful for the dermatologist for the visual examination of skin. In most of the rural areas it is difficult for the people to consult a dermatologist. It is mainly because of that the cost of consulting a dermatologist is not affordable to people. Diagnosis of skin disease is extremely difficult due the presence of hair and other related factors. The spread of these disease is very rapid and need to be taken care off. For the traditional diagnosis it requires a long laboratory test for the identification of these disease[2]. Nowadays lasers and photonics are also available for the diagnosis. Even though there are diagnosing measures these may not be accurate and affordable for the local people. Since, the spread of disease is very rapid it need to be treated at the earliest. Skin disease affect physical and mental well being of a human being. If the disease is not treated at the earliest it can result in wide spread all over the body and even can result in cancer. Usually home remedies are taken for the diagnosis if these remedy is not apt for the particular disease then result will be even worse. There are different type of disease which affect the skin mainly melanoma, rashes, dermatitis, eczema etc. Mostly, the disease are caused by fungal, bacterial and virus, etc. But some infections may occur in skin if there is internal organ failure/disease[3].

Machine learning and pattern recognition can improve the accuracy of prediction of diseases through image processing techniques like support vector machines and a few pattern recognition techniques and computer vision[3]. Deep neural networks are the emerging techniques utilized in different fields for image classification, prediction, through computer vision. CNN may be a multi-layer neural network with a supervised learning architecture that's often made from two parts: a feature extractor and a trainable classifier. There's a feature extractor, it contains feature map layers and retrieves discriminating features from the raw images via two operations: convolutional filtering and down sampling. The key operation of CNN in convolutional filtering has two vital properties: local receptive field and shared weights. Convolutional filtering are often seen as an area feature extractor wont to identify the relationships between pixels of a raw image in order that the acceptable high-level and effective features of images are often extracted to reinforce the generalization ability of a CNN Model[3]. Furthermore, down sampling and weight sharing can greatly reduce the amount of trainable parameters and improve the efficiency of coaching. Within the feature extractor, the classifier and therefore the weights are learned and are trained by a back-propagation algorithm[3].

Support vector machines are supervised learning models with associated learning algorithms that analyze data used for classification and multivariate analysis. A typical machine learning algorithm tries to seek out a boundary that divides the info in such how that the misclassification error are often minimized. SVM differs from the opposite classification algorithms within the way that it chooses the choice boundary that maximizes the space from the closest data points of all the classes[4]. An SVM doesn't merely find a choice boundary; it finds the foremost optimal decision boundary. The foremost optimal decision boundary is that the one which has maximum margin from the closest points of all the classes. The closest points from the choice boundary that maximize the space between the choice boundary and therefore the points are called support vectors within the case of non-linearly separable data, like the one a line can't be used as a choice boundary. Just in case of non-linearly separable data, the straightforward SVM algorithm can't be used. Rather, a modified version of SVM, called Kernel SVM is used. Basically, the kernel SVM projects the non-linearly separable data lower dimensions to linearly separable data in higher dimensions in such how that data points belonging to different classes are allocated to different dimensions[5].

Literature reveiew: AlEnezi[1] proposed a image processing based system. This method takes the digital image of disease effect skin area, then use image analysis to identify the type of disease. The diseased image is given as an input to convolutional neural network and the features is extracted. The extracted feature is again given as an input to Multiclass SVM for further classification. Yasir *et al*.[2] proposed a system which uses computer vision based techniques to detect various kinds of dermatological skin diseases. Different types of image processing algorithm is used to extract feature from the dataset. Feed forward neural network is used for training and testing purpose. The system works on two phases-first pre-process the color skin. Images to extract significant features and later identifies the diseases. The system successfully detects 9 different types of dermatological skin diseases with an accuracy rate of 90%. The system attains only 90% accuracy since it detect 9 different types of disease it is very important to have a system with higher accuracy rate. The proposed method does not do any preprocessing steps as it is also important for any classification system. The dataset is collected from various resources and it contain many noises too which adversely effects its performance. The training accuracy is weaker and the model can be improved by adding new layers.

Patnaik *et al*.[3] proposed a system which uses three publicly available image recognition architectures namely Inception V3, Inception Resnet V2, Mobile Net with modifications for skin disease application and successfully predicts the skin disease based on maximum voting from the three networks. The system consists of three phases-the feature extraction phase, the training phase and the testing/validation phase. The system makes use of deep learning technology to train itself with the various skin images. The main objective of this system is to achieve maximum accuracy of skin disease prediction. The system uses different architecture for the classification of diseases. At the end, result is produced based on the maximum voting which can be wrong and lead to a complex architecture and even time consuming to run each model at the time. Different architecture might produce different disease as the result. Arifin *et al*.[4] proposed a system which work on two dependent steps-the first detects skin anomalies and the latter identifies the diseases. The system operates on visual input, i.e, high resolution color images and patient history. In terms of machine intervention, the system uses color image processing techniques, k-means clustering and color gradient techniques to identify the diseased skin. For disease classification, the system resorts to feed forward backpropagation artificial neural networks. The system exhibits a diseased skin detection accuracy of 95.99% and disease identification accuracy of 94.016% while tested for a total of 2055 diseased areas in 704 skin images for 6 diseases. RGB images requires high processing capacity. The testing accuracy of the system is lower than the training accuracy. The system does-not perform any preprocessing steps as the dataset contain many types of noise. A system can be developed to increase the accuracy of results by including proper preprocessing steps. Only a few number of diseased image is used for the training as neural network often requires more number of images for getting an optimum result.

Albawi *et al*.[5] proposed a system in which three types of skin diseases such as Melanoma, Nevus and Atypical is detected. For pre-processing an adaptive filtering method was designed to remove unwanted noisy areas from the input skin image. For segmentation, adaptive region growing technique was developed for efficient localization and Region of Interest (ROI) extraction of disease area. This segmentation adaptively selects the next region to grow for accurate lesion segmentation. For feature extraction a hybrid feature extraction method composed of 2 Dimensions Discrete Wavelet Transform (2D-DWT), geometric and texture features. It uses a simple adaptive filter for the noise removal there can be chance of blurriness or distortion of edges as some filers does not preserve edges. The deep learning algorithm performs the classification. The proposed method can classify the skin diseases with accuracy of 96.7% Suganya *et al.*[6] proposed a system which uses k-means clustering for segmentation. After lesion is segmented the features such as color, text and shape is extracted. Many methods are used for classification but they focus only on melanocytic skin lesion, i.e., detecting melanoma only. Other lesion should also be classified for that a novel approach is used in this paper. The Support Vector Machine (SVM) classifier was used for classification of skin lesions such as Melanoma, Basal Cell Carcinoma (BCC), Seborrhoeic Keratosis (SK) and Nevus. The dataset collected is from Dermweb. Extracting the affected area is an important task. Since, the disease can spread from one to another there is a chance of extracting only a defined portion from the images by this particular method.

Alam *et al*.[7] proposed a system that can detect regions of eczema and classify the identified region as mild or severe based on image color and texture feature. Then the model automatically measures skin parameters used in the most common assessment tool called ”Eczema Area and Severity Index (EASI)” by computing eczema affected area score, eczema intensity score and body region score of eczema allowing both patients and physicians to accurately assess the affected skin. The system detect only one type of disease that is eczema and classify it as mild and severe. The disease is detected based on the parameters of EASI. There can be variation in parameters based on the skin type, tone and presence of hair. Kumar *et al*.[8] proposed a system which use a dual stage approach which effectively combines Computer Vision and Machine Learning on clinically evaluated histopathological attributes to accurately identify the disease. In the first stage, the image of the skin disease is subject to various kinds of pre-processing techniques followed by feature extraction. The second stage involves the use of Machine learning algorithms to identify diseases based on the histopathological attributes observed on analyzing of the skin. Upon training and testing for the six diseases, the system produced an accuracy of up to 95%.

Krizheusky *et al*.[9] proposed a system which successfully detects different types of dermatological skin diseases. It consists of mainly three phases image processing, training phase, detection phase. In image processing phase we apply algorithms like gray scale conversion, RGB to HSV conversion to the input image. After getting HSV values disease corresponding to the input image gets detected by artificial neural network algorithm. Also, as an addition to the detection the percentage of infection is identified. Chang and Liao[10] proposed an automatic facial skin defects detection and recognition system. The system automatic locates the facial region and extracts region of interest. A support-vector-machine-based classifier is then used to classify the potential defects into spot, acne and normal skin. The system cares only about the facial diseases. A system is needed to identify the disease which affects any body parts. Ganna *et al*.[11] proposed a system to diagnose Melanoma in early stages, the image processing technique is used the initial process to detect the pigment skin lesion is benign or malignant and the later to recognize malignant melanoma skin type. The process is further carried out by lesion segmentation and feature extraction. Diagnosis is carried out to differentiate

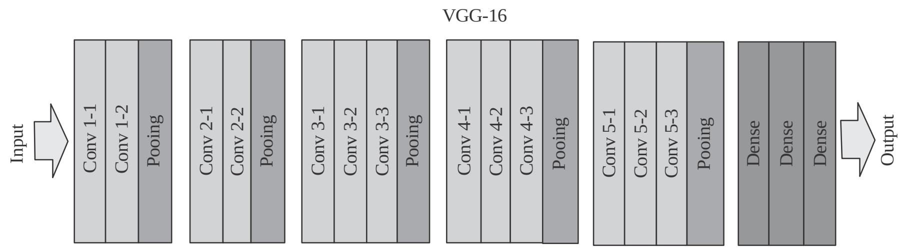

Fig. 1: Architecture of VGG-16

between benign and malignant melanoma. Hence, it can give a different type of malignant melanoma such as superficial, nodular, lentigo and acral melanoma. The study focuses only on melanoma.

From the above studies, we can understand that many methods are used for the classification of skin disease but a less importance is given in preprocessing stage and also Most of the studies have utilized the dermatoscopic dataset of diseases. In our study separate dataset has been created with the images of Rashes and healthy skin from various resources. The proposed work mainly focuses on the preprocessing stage where a number of preprocessing methods is done on the images to get an accurate result. In the proposed work mainly detect the disease melanoma, rashes along with healthy skin. In the preprocessing stage hair removal, image sharpening, bilateral filter, conversion of RGB to Grayscale and Image Augmentation is done. Feature extraction also plays an important role in the classification. VGG16 which is well known convolutional neural network is used for the feature extraction. It has the capability to learn more complex features as more convolution layers are in the stack with smaller filter sizes compared to AlexNet. With the extracted feature classification is done with SVM, Random forest and kNN SVM and Random forest resulted in same accuracy of 98%.

Architectureof VGG-16: Convolutional Neural Network (CNN) may be a sort of artificial neural network utilized in image recognition and processing that's specifically designed to process pixel data[4]. CNNs are used for efficient image processing, Artificial Intelligence (AI) that use deep learning to perform both generative and descriptive tasks, often using machine vision that has image and video recognition, alongside recommender systems and tongue processing (NLP).

Vgg16 is a convolutional neural network architecture. Its name VGG-16 comes from the fact that it has 16 convolutional layers. The layered structure consists of Convolutional layers, max pooling layers, Activation Layers and Fully connected layers 5 max pooling layers and 3 Dense layers which sums up to 21 layers but only 16 weight layers Conv 1 has number of filters as 64 while conv 2 has 128 filters, conv 3 has 256 filters while conv 4 and conv 5 has 512 filters. It is the base architecture and capable of retrieving minute features. The input to the network is image of dimensions (224, 224, 3). The first two layers have 64 channels of 3*3 filter size and same padding. Then after a max pool layer of stride (2, 2), two layers which have convolution layers of 256 filter size and filter size (3, 3). This followed by a max pooling layer of stride (2, 2) which is same as previous layer. Then there are 2 convolution layers of filter size (3, 3) and 256 filter. After that there are 2 sets of 3 convolution layer and a max pool layer. Each have 512 filters of (3, 3) size with same padding. This image is then passed to the stack of two convolution layers. In these convolution and max pooling layers, the filters we use is of the size 3*3 instead of 11*11 in Alex Net In some of the layers, it also uses 1*1 pixel which is used to manipulate the number of input channels. There is a padding of 1-pixel (same padding) done after each convolution layer to prevent the spatial feature of the image (Fig. 1).

Different types of skin diseases: This study briefly describes different types of diseases that occur on skin. The reason behind the given section is that the readers can understand about what types of image processing operations would be needed and what type of features need to be considered to prepare such disease detection system.

Melanoma: Melanoma is a serious type of skin cancer develop in the cell which produce melanin. Symptoms of melanoma is a change in an existing mole. The development of a new pigmented or unusual-looking growth on your skin[7].

Rashes: A rash is a noticeable change in the texture or color of your skin. Your skin may become scaly, bumpy, itchy or otherwise irritated. Usually located in clusters on the lower legs and feet itchy, red bump surrounded by a red halo symptoms begin immediately after being bitten The images o f two frequently occurring disease are shown Fig. 2.

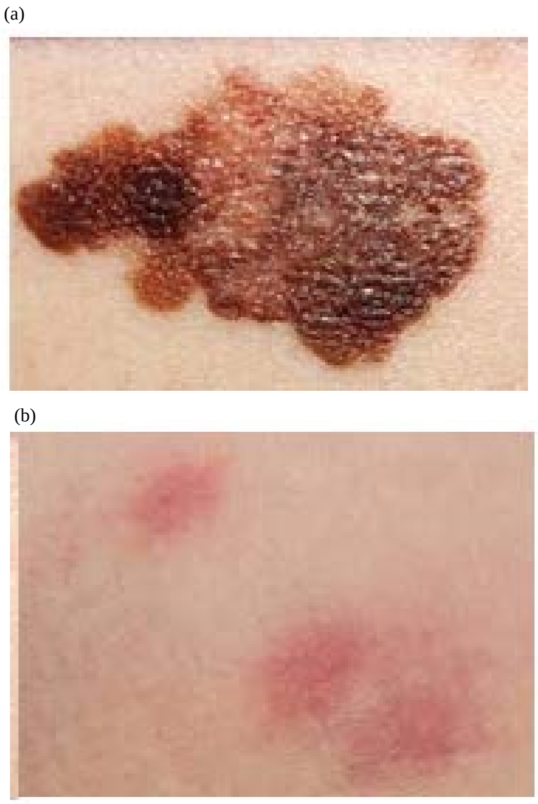

Fig. 2(a, b): Melanoma rashes

MATERIALS AND METHODS

Proposed work: In our proposed system, we aim to detect two main skin disease mainly Melanoma, rashes along with healthy skin.

Image acquisition: Images of Melanoma were collected from the famous skin image repository HAM10000 dataset. A total of only 300 images were collected from the repository. Images of Rashes and healthy skin were collected from various resources in the Internet. A total of 600 images were collected.

Image preprocessing: Various preprocessing steps is done on the dataset to remove noise from the images. The steps include:

Hair removal: Presence of hair in images can affect the results from getting an accurate results. The features of hair will also get extracted when these images are given to the model for feature extraction. Thus it is very necessary to remove the hair from the images. In order to remove the hair Morphological Filter is used. Morphological Black hat transformation is applied first to extract the dark portion from the bright thus the portion with hair is extracted. After black hat transformation Inpainting is used. Inpainting is used to create a mask for the hair by taking pixel average of its neighbors which is the fast marching method:

$$I_q(p) = I(q)+\nabla I(q)(p-q)$$

Where:

I_q = The image
p = The point in the image which is to be in painted
∇ = The gradient frunction

The in painting values of p is the value which is close to p. $\partial\Omega$ denote the boundary of the region Ω to be in painted for small ε we consider the first order approximation I_q (p) of the image in point p. ε is the area around unknown point p.

Image sharpening: Some of the image acquired from various resources were not up to the quality. Since, the disease can spread from affected region to the nearby region it is important to get the details of neighborhood also. In order to get the fine details from an image sharpening is used. Image sharpening refers to any enhancement technique that highlights edges and fine details in an image. A kernel is used for the sharpening. Kernal along with the original image results in the sharpened image. It increases the contrast between bright and dark region to bring out the region. Image sharpening is given by:

$$S_{i,j} = x_{i,j}+\lambda F(x_{i,j})$$

Where:

$x_{i,j}$ = The original pixel value at the coordinate (i, j)
F = The high pass filter
λ = Parameter greater than or equal to 0.S is the sharpened pixel at the coordinate (i ,j)

In order to sharpen the image we need a pass a filter to the image. For every pixel [x, y] of the image consider first its red-value component. This will be an integer between 0 and 255. They are based on first and second order derivates. Since, in image processing, we deal with discrete quantities, the definitions for the discrete first and second derivatives should be used. First order derivatives are used to produce thicker edges in an image and are usually used for edge extraction. Second order derivatives on the other hand have a stronger response to fine detail and are usually better for image enhancement than the first order derivatives. One sharpening filter is the Laplacian. The Laplacian is a linear operator and it forms an isotropic filter. In order to get a sharpened image, typically, the resulting Laplacian filtered image (or a weighted version of it) is added to the original image. In practice, a mask is typically used that will carry out both steps at once. The Laplacian is given by:

$$\Delta^2 f = \frac{\delta^2 f}{\delta x^2} + \frac{\delta^2 f}{\delta y^2}$$

Bilateral filter: Bilateral filter is applied after image sharpening. Images may contain some types of noise. In order to remove any such noise such as salt and pepper etc. we use bilateral filter. A bilateral filter is used for smoothing images and reducing noise while preserving edges. Other filter reduces noises but results in blurring out and loss of edge information. We need to prevent the loss of edge information as it is needed for getting an accurate result:

$$BF[I]_P = \frac{1}{W_P}\sum_{Q\varepsilon S} G\sigma_S\left(\| P\text{-}q \|\right) G\sigma_r\left(| I_p\text{-}I_Q |\right) I_q$$

Where:

$BF[I]_p$ = The result at pixel p
I_q = The intensity at pixel q
σ_s = Denotes the spatial extent of the kernel, i.e., the size of the neighborhood
σ_r = Denote the minimum amplitude of the edges

It ensures that only those pixels with intensity values similar to that of the central pixel are considered for blurring while sharp intensity changes are maintained. The smaller the value of σ_r the sharper the edge σ_r tends to infinity, the equation tends to a Gaussian blur. Bilateral filter is done with thee extension of Gaussian function.

RGB to gray scale: In order to reduce the complexity of running color images, RGB images is converted to gray scale. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. In fact a ‘gray’ color is one in which the red, green and blue components all have equal intensity in RGB space and so, it is only necessary to specify a single intensity value for each pixel as opposed to the three intensities needed to specify each pixel in a full color image.

Image augmentation: Data augmentation is a technique which avoids over fitting and improve the accuracy. In this work, different augmentation methods such as zooming, rotating at 40° Angles is done. After the Augmentation a total of around 2000 images where generated.

Feature extraction: In this study, well known pretrained convolutional model VGG16 is used for the feature extraction. A set of feature is extracted by this model which are used for the further classification thus feature extraction is an important step in this study. From the input layer to the last max pooling layer is regarded as feature extraction part of the model while the rest of the network is regarded as classification part of the model. VGG16 Model is used without using the final fully connected layers. After defining the model, we need to load the input image with the size expected by the model, after defining the model we need to convert the image into Numpy array of pixel data. The pixel values then need to be scaled appropriately for the VGG Model. The convolution operation is performed using a kernel of dimension 3×3 with learnable parameters W and b passed over the pixels x of an each image which results in output y. The movement of the kernel is either. Pixel wise or skipping of several pixels which is determined by the stride. The simplified version of the convolution operation is represented by the function as follows:

$$Y = f\left(Wx+b\right)$$

The initial convolutional layer extract more simple features like edges, corners, etc. Initial convolutional layer extract these features later layers extract more complex features and combine. In this model pretrained weights on the image Net is used and modified fully connected layers of the network. Remove the output layers the one which give the probabilities for being in each of the classes and the entire network is used as a feature extractor.

Classification

Support vector machine: SVM is a supervised machine learning method that can be used for regression and classification problems. SVM searches a hyper plane that separates the positive data from the negative data with maximum margin. The extracted feature from the pre-trained network is given as an input to the support vector machine for the classification. SVM takes these features for classifying disease. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes, so that, we can easily put the new data point in the correct category in the future. In this study linear SVM is used for the classification which takes a lower dimensional data and transfer in to higher dimensional data. SVM generate a hyper plane in an iterative manner which accurately classify the disease:

$$u = \vec{w}.\vec{x}\text{-}b \tag{1}$$

$$\frac{1}{2}| w |^2 \tag{2}$$

$$y_i\left(\vec{w}.\vec{x}\text{-}b\right) \geq \forall i \tag{3}$$

The formula for the output of a linear SVM is given in Eq. 1 where $\vec{w}$ is the normal vector to the hyperplane and $\vec{x}$ is the input vector. Maximizing margins can be defined as an optimization problem: minimize (Eq. 2) subject to Eq. 3 where is ith training example and y_i is the correct output of the SVM for ith training example:

kNN: k-Nearest Neighbors (kNN) is a non-parametric method based on distance measurement between the features of the training set. The classification is realized using the distance between the selected features and the k-nearest neighbors. When implementing kNN, the first step is to transform data points into feature vectors or their mathematical value. The algorithm then works by finding the distance between the mathematical values of these points. kNN runs the formula to compute the distance between each data point and the test data. It then finds the probability of these points being similar to the test data and classifies it based on which points share the highest probabilities.

In this study, k value was adjusted to three and the Euclidean was used as a distance function. To measure the distance between points A and B in a feature space. Let A and B are represented by feature vectors A = (x1, x2, ..., xp) and B = (y1, y2, ..., yp) where p is the dimensionality of the feature space:

$$d(A,B) = \sqrt{\sum_{k=1}^{p}(x_1-y_i)^2} \quad (4)$$

Random forest: The random forest classifier is a set of decision trees from randomly selected subset of training set. It aggregates the votes from different decision trees to decide the final class of the test object. It is one of the most accurate learning algorithms available. For many data sets, it produces a highly accurate classifier. The difference between random forest algorithm and the decision tree algorithm is that in random forest, the process of finding the root node and splitting the feature nodes will run randomly:

$$G = 1-\sum(p_i)^2 \quad (5)$$

$$\text{Enteropy} = \sum_{i=1}^{c}-(p_i * \log_2 p_i) \quad (6)$$

In Eq. 5, uses the class and probability to determine the Gini (G) of each branch on a node, determining which of the branches is more likely to occur. Here, p_i represents the relative frequency of the class you are observing in the dataset and c represents the number of classes.

RESULTS AND DISCUSSION

The proposed CNNs Model is applied to skin disease detection problem. We use about 2000 labeled images of 2 disease along with healthy skin (Fig. 3-5 and Table 1 and 2).

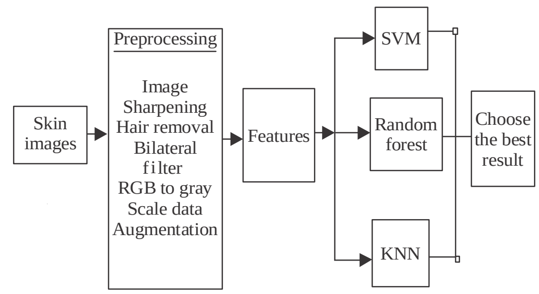

Fig. 3: Block diagram of system flow

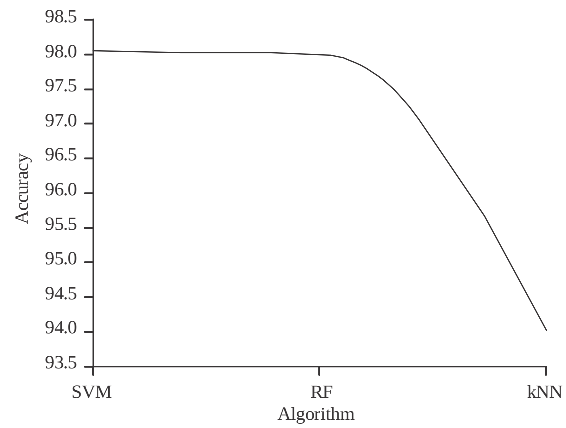

Fig. 4: Graphical representation of result

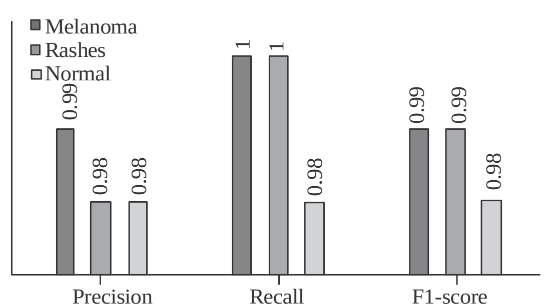

Fig. 5: Metrices-SVM

Table 1: Simulation results of proposed model

Algorithm	SVM	RF	kNN
Accuracy (%)	98	98	94

Table 2: Metrices

SVM	Precison	Recall	F1-score
Melanoma	0.99	1.00	0.99
Rashes	0.98	1.00	0.99
Normal	0.98	0.98	0.98

Graphical representation of result: From the above results we can understand that Vgg16 used with SVM and random forest has acquired the highest accuracy of about 98% whereas SVM with kNN could give only 94%. VGG16 with SVM or VGG16 with random forest can be used for the final classification of disease.

CONCLUSION

The current study focused on the diagnosis of common skin disease in human. For the diagnoses,3 diseases Melanoma, rashes and healthy skin is used. For the feature extraction a pre-trained network of CNN, VGG16 is used. Various preprocessing techniques have been applied to the image to remove the noises present in the images and to get a more accurate result. These preprocessed images are given to the network for the feature extraction. The extracted features are fed in to the various algorithm like SVM, kNN and random forest for the classification.

From the analysis, we can understand that SVM August 4, 2020and Random Forest gives the highest accuracy rate of about 98% whereas kNN could give only 94%. Even though SVM and random forest gives the same testing accuracy the mainly focus only on SVM as random forest requires large memory and time for the processing. Thus SVM outperforms random forest. The results of this study point out that the deep image features provided robust and consistent features for skin disease detection and the SVM classifier increased the efficiency of the classification.

REFERENCES

01. ALEnezi, N.S.A., 2019. A method of skin disease detection using image processing and machine learning. Procedia Comput. Sci., 163: 85-92.
02. Yasir, R., M.A. Rahman and N. Ahmed, 2014. Dermatological disease detection using image processing and artificial neural network. Proceedings of the 8th International Conference on Electrical and Computer Engineering, December 20-22, 2014, IEEE, Dhaka, Bangladesh, pp: 687-690.
03. Patnaik, S.K., M.S. Sidhu, Y. Gehlot, B. Sharma and P. Muthu, 2018. Automated skin disease identification using deep learning algorithm. Biomed. Pharmacol. J., 11: 1429-1437.
04. Arifin, M.S., M.G. Kibria, A. Firoze, M.A. Amini and H. Yan, 2012. Dermatological disease diagnosis using color-skin images. Proceedings of the 2012 International Conference on Machine Learning and Cybernetics Vol. 5, July 15-17, 2012, IEEE, Xian, China, pp: 1675-1680.
05. Albawi, S., Y.A. Abbas and Y. Almadany, 2018. Robust skin diseases detection and classification using deep neural networks. Int. J. Eng. Technol., 7: 6473-6480.
06. Suganya, R., 2016. An automated computer aided diagnosis of skin lesions detection and classification for dermoscopy images. Proceedings of the 2016 International Conference on Recent Trends in Information Technology (ICRTIT), April 8-9, 2016, IEEE, Chennai, India, pp: 1-5.
07. Alam, M.N., T.T.K. Munia, K. Tavakolian, F. Vasefi, N. MacKinnon and R. Fazel-Rezai, 2016. Automatic detection and severity measurement of eczema using image processing. Proceedings of the 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), August 16-20, 2016, IEEE, Orlando, Florida, pp: 1365-1368.
08. Kumar, V.B., S.S. Kumar and V. Saboo, 2016. Dermatological disease detection using image processing and machine learning. Proceedings of the 2016 3rd International Conference on Artificial Intelligence and Pattern Recognition (AIPR), September 19-21, 2016, IEEE, Lodz, Poland, pp: 1-6.
09. Krizhevsky, A., I. Sutskever and G.E. Hinton, 2012. Imagenet Classification with Deep Convolutional Neural Networks. In: Advances in Neural Information Processing Systems, Leen, T.K., G.D. Thomas and T. Volker (Eds.). MIT Press, Cambridge, Massachusetts, USA., ISBN: 0-262-1 2241-3, pp: 1097-1105.
10. Chang, C.Y. and H.Y. Liao, 2011. Automatic facial skin defects detection and recognition system. Proceedings of the 2011 5th International Conference on Genetic and Evolutionary Computing, August 29-September 1, 2011, IEEE, Xiamen, China, pp: 260-263.
11. Gaana, M., S. Gupta and N.S. Ramaiah, 2019. Diagnosis of skin cancer melanoma using machine learning. Mach. Learn., Vol. 1,