A Convolutional Neural Network Approach in Diagnosis of Skin Disease

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***Abstract*—** *Skin disease diagnosis or dermatology is one of the most difficult field. Several tests are to be carried out so as to decide upon the skin disease the patient may be facing. This takes time based on the diagnosis prediction. So there comes the need of a system which can diagnose the skin diseases without any of these constraints and provide better results in just fraction of seconds. Here an automated image-based system using convolutional neural network for recognition of skin diseases is proposed. Training data set are required for various skin diseases. Skin images are filtered to remove unwanted noise and pigments. Feature extraction is done to bring the image to our required dimension. The output from feature extraction unit is fed into classifier unit. The input attributes like shape and texture etc. are taken from the user input and fed into classifier. The classifier used is softmax classifier which is based on probability. The testing data and training data are compared based on probability. Each disease is assigned a unique class label. If the disease belongs to one of the training datasets, then the software predicts what disease it is otherwise a message reporting the image does not match with the data.*

I. INTRODUCTION

Skin is an important sense organ in protecting the body against pathogens and water loss. Insulation, temperature regulation, sensation, vitamin D synthesis and vitamin B protection are the other functions of skin. It acts as first line of defense against foreign particles and anti-agents entering into the body. It is a shield. The outermost layer is epidermis. Dermatological diseases are the most common. Proper knowledge and experience in dermatology is required for accurate diagnosis. Precautious and preventive measures can control skin disease to a large extent. Early detection of skin diseases is the very need of the hour. Skin disease can impact on quality of life for patients. Some diseases are malignant and need proper care and attention. As skin is one of the sensory organs, at most care is required.

Environmental factors together with the other causes are the main factors of skin diseases. Easily available detection schemes are to be made for early diagnosis of skin disease. Here the proposed paper provides an approach to detect various kinds of the diseases like psoriasis, melanoma, not melanoma, ringworm and measles. The user gives input of the skin disease image, which then the system processes, does feature extraction using CNN algorithm and use softmax image classifier to diagnose diseases. If no disease is found, that does not match with the dataset then disease not found message is displayed. Human skin shows wide variety of colors from the darkest brown to the lightest pinkish - white. Natural selection is the reason why humans exhibit large color variations. Skin pigmentation in humans is caused due to the amount of ultraviolet radiation (UVR) penetrating the skin, controlling its biochemical effects.

Melanin is the factor that determines the color of human skin. The system identifies the color of the skin to distinguish the disease. Skin color varies for various diseases. Based on the skin color and various other attributes like border, shape and texture the disease can be found out.

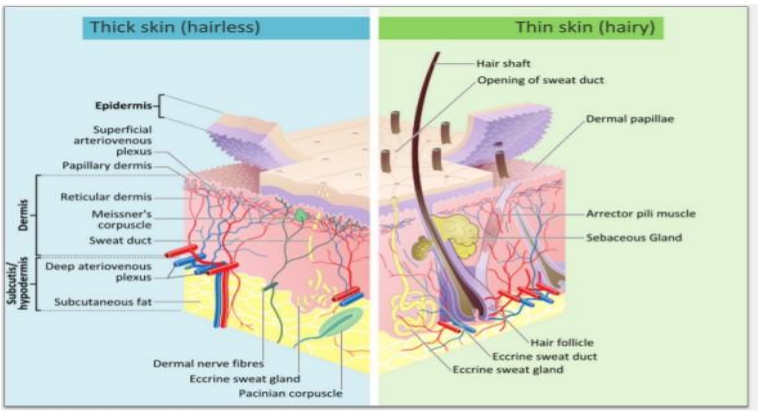


FIGURE 1: Structure of skin

II. LITERATURE SURVEY

2.1 Dermatological Disease Detection Using Image Processing and Machine Learning

In order to diagnose skin disease, the system utilizes a two staged approach. In this approach the Image Processing for identification is the first stage and Machine Learning is the second stage. The system acts as an effective learning tool, aiding verification of the results as it has access to clinical data. The machine learning data repository provides the training data set. By using Computer Vision and Machine Learning algorithms the system has achieved better accuracies. The system is capable of detecting six diseases, namely Psoriasis, Seborrheic Dermatitis, Lichen Planus, Pityriasis Rosea, Chronic Dermatitis, and Pityriasis Rubra Pilaris.

The type of skin disease can be identified by considering the numerous features extracted from the image and this is identified by Computer Vision in the first stage. In the second stage the system uses various Machine Learning techniques to refine the classification of the image. The second stage of prediction is made available to the medical professionals who have access to various histopathological attributes like exocytosis, hyperkeratosis, acanthosis, parakeratosis and other attributes. To obtain better classification of the disease, the system takes these attributes as input from the user.

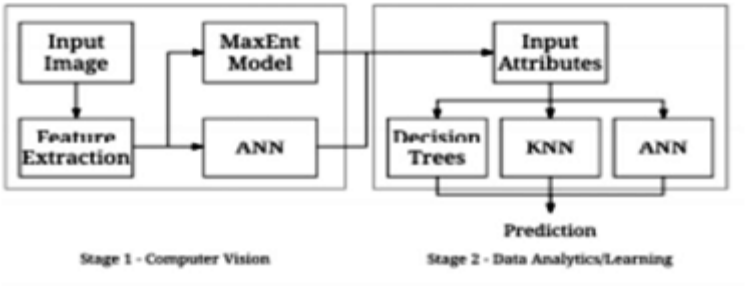


FIGURE 2: Block Diagram

Using Decision Trees, Neural Networks and kNN (kth Nearest Neighbor) model, the system tested and trained using the dataset obtained from the repository. To convert input image to grey scale image, sharpening filter, median filter, smooth filter, binary mask, RGB extraction, histogram and Sobel operator the algorithms are useful. Before converting to grayscale image, the RGB values are extracted from the image. To sharpen the details of the infected region, sharpening filter is applied to the grayscale image. After sharpening the image, to remove the noise from the image the Median Filter is used. The smoothing filter is used to replace each pixel with the mean values of its neighbors, including itself. By using mean filtered image and distribution of color of binary image, binary image is generated. In order to extract average color code of the infected area from the binary image, YCbCr is used. To detect the edge of the infected area Sobel operator is applied to binary image.

The inflicted region's histogram is obtained. RGB color space of the image is converted into HSV color space. A feed forward ANN with back propagation is also tried along with the Maximum Entropy model for the same features which are extracted. The ANN consisted of one input layer, two hidden layers and an output layer.

The mobile application based on the principles as described above produce better results than any application. Combining the two stages increases the accuracy, making the application an efficient, accurate and good system for dermatological disease detection. This can be used as a good teaching tool in medical field. As an add on, the application can also be used by the common user as it has been able to achieve fairly accurate detection rate by Computer Vision techniques alone.

2.2 Skin Disease Recognition Using Texture Analysis

The system is based on the texture analysis using neural network. As the complexity and number of features of the disease increases, the disease diagnosis and recognition become difficult. This led to a computer aided diagnosis and recognition system. The system involves steps like image processing, image feature extraction and classification of data using artificial neural network. The ANN is capable of learning the patterns of symptoms of particular diseases and provides faster diagnosis. This helps the patients to do the treatment for the skin disease immediately based on the visible symptoms.

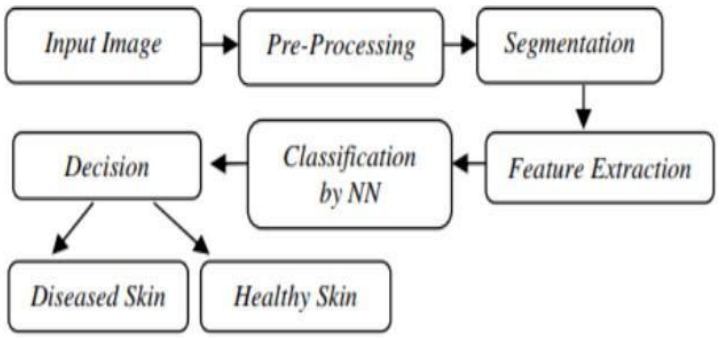


FIGURE 3: Block Diagram of the System

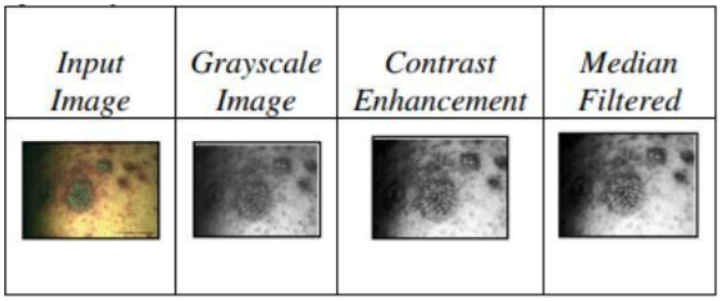


FIGURE 4: Processing of images

The block diagram involves two sections: Image Processing and Classification. The architecture involves the following steps: Image acquisition, Pre-Processing, Segmentation, Feature Extraction, Classification using neural network and decision phase is used to find whether the skin is affected with disease or not. Feature extraction is used to differentiate between each input patterns. Texture analysis using Grey Level Co-occurrence Matrix (GLCM) provides the basis of feature extraction. GLCM maps the grey level co-occurrence probabilities into different angular directions. The extracted features from GLCM include Energy, Correlation, Homogeneity and Contrast:

Neural network classifier is used for segmenting the image. The input layer, hidden layer and output layer are the layers in feed forward multilayer network. Back propagation algorithm is used and the signal will flow in the forward direction. If both outputs do not match, the output of the network being compared with desired output, an error signal will be generated. To reduce the error, the signal is propagated backwards and weights are adjusted. At the beginning of training, the hidden layer and output layer are initialized. The process continuous until the error is zero.

2.3 An Automated Computer Aided Diagnosis of Skin Lesions Detection and Classification for Dermoscopy Images

Skin cancer is a deadly disease nowadays. So, early detection and prevention are essential. Skin cancer is defined as the uncontrolled and unpredictable growth of cells in the skin. The main causes of skin cancer is the over exposure of ultraviolet radiation from sunshine, genetic defects and food habits. There are mainly three types of skin cancer such as Basal cell carcinoma (BCC), Melanoma, and Squamous cell carcinoma (SCC). The non-melanomas were BCC and SCC. To classify the skin lesions in accurate manner an automatic Computer-Aided Diagnosis (CAD) for dermoscopy images is needed. The flow diagram gives the classification model for skin cancer such as Melanoma, Nevus, Basal cell carcinoma and Seborrhoeic keratosis which can classify both Melanocytic skin lesions (MSLs) and Non-melanocytic skin lesions (NoMSLs) .

2.3.1 Pre-processing

The image of the affected part is given as the input to the system. The image contains hair that must be eliminated in the pre-processing. It is removed using Dull Razor software. The median filter was used for removing thick hair after which circular averaging filter of size r is used for smoothing.

2.3.2 Border detection method

After pre-processing, convert the RGB image to grayscale image and identify the pixels whose intensities are less than 200 of the images. Identified pixels of the image with disk size 3r are dilated to include border of the microscope areas that are not selected. K-means clustering is used to segment the region.

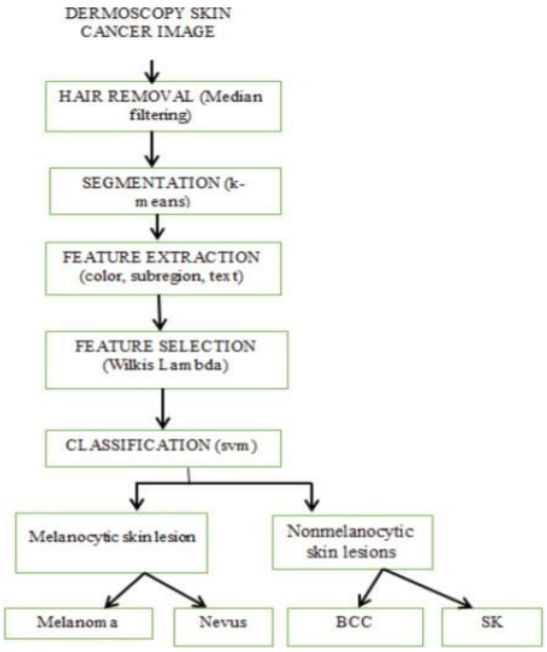


FIGURE 5: Representation of the System

2.3.3 Classification

Segmenting the lesion of skin image into three regions-normal skin, peripheral, tumor after detecting the border of the skin lesion is the final step. The SVM classifier is used for classification. It first classifies the Melanocytic skin lesion from Nonmelanocytic skin lesions and classifies the melanoma from nevus for MSLs and for basal cell carcinoma from seborrhoeic keratosis in NoMSLs. The first step classifier (MN-BS) is used to distinguish MSLs from NoMSLs and second step classifier distinguish melanoma from nevus (M-N) and distinguish basal cell carcinoma from seborrhoeic keratosis (B-S). The M, N, B, S stands for melanoma, nevus, basal cell carcinoma and seborrhoeic keratosis for classification model by using SVM classifier. This method for classification has achieved better accuracy.

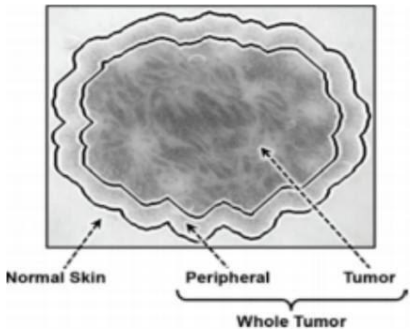


FIGURE 6: Four regions of skin lesions

FIGURE 7: Implementation results by SVM classifier for melanoma

2.4 Dermatological Disease Detection using Image Process- ing and Artificial Neural Network

The results of image pre-processing and user inputs like liquid type, liquid color, elevation, duration, feeling, gender and age are fed into the system. The training and testing purpose of the feed forward artificial neural networks (ANN) are based on these features. Diagnosis can be made effective by using artificial neural networks (ANN) as knowledge base. Pre-processing of skin images followed by segmentation and feature extraction are the two phases in the system. Colour skin images and 8 different image processing algorithms are applied on to the system. The training is done in such a way that the user input

values along with colour skin image extracted features are given to a feed forward back propagation artificial neural network to identify the dermatological disease.

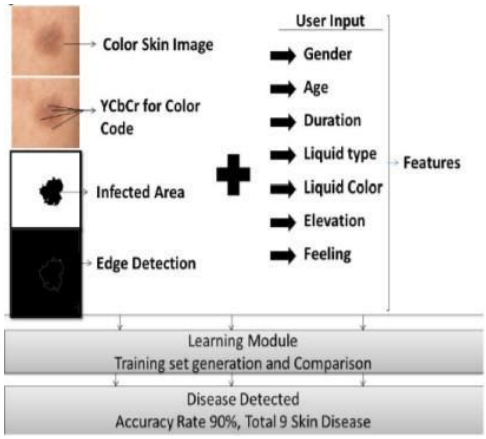


FIGURE 8: System architecture

The eight different algorithms used are grey image, sharpening filter, median filter, smooth filter, binary mask, histogram, YCbCr and sobel operator. The algorithms are implemented sequentially. Grayscale image of the infected area is obtained first. Sharpening filter is applied to the grayscale image to get sharper details of the infected area. To remove noise, median filter is used. 5*5 matrix is used as median filter and smoothing filter is applied after media filter. From the mean filtered image, the binary image is obtained and color distribution of binary image is represented by histogram. To extract average color code of the infected area from the binary image, YbCr is used. To detect edge of the infected area, sobel operator is used.

Feed-forward back-propagation neural network training is the final step. Tenfold cross validation is used for validation and testing of the system. To avoid the overlapping of the testing data and training data and making the system testing results viable and dependable, the system uses cross validation technique. The feed forward back-propagation neural network is trained with 10 different features, in which three are from image features and seven are from user inputs. In the system, 100 neurons are used in the hidden layer to get the best result from the system.

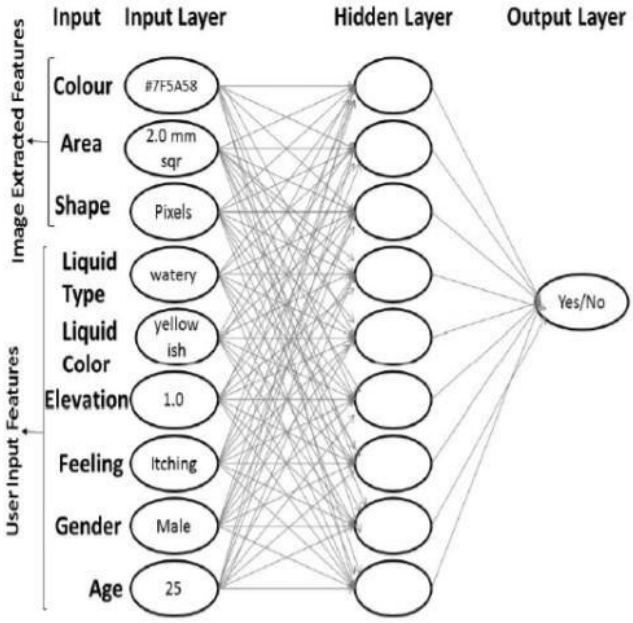


FIGURE 9: Feed forward neural network

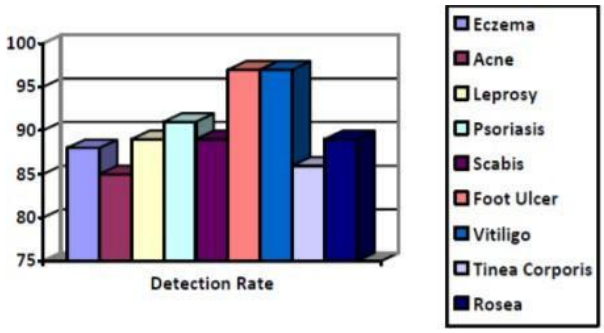


FIGURE 10: Detection rate of different skin diseases

Low elevation in the infected area of diseases like foot ulcer, vitiligo and psoriasis are very high like 97%, 97% and 91% whereas the diagnosis of diseases that has low elevation are comparatively low which is between 85-88diseases, the system shows good accuracy rate for foot ulcer and vitiligo and the system did not perform well for acne and tinea corporis.

2.5 Dermatological Disease Detection using Image Process ing and Artificial Neural Network.

Skin diseases are among the most common health problems worldwide. In this article we proposed a method that uses computer vision-based techniques to detect various kinds of metrological skin diseases. We have used different types of image processing algorithms for feature extraction and feed forward artificial neural network 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.

2.6 Detection of Vitiligo Skin Disease using LVQ Neural Net- work

Digital image processing is a combination of various algorithms and technique to process different types of images. It is applied in various types of images to process and get a valuable outcome from the image. The Digital image processing is the experimented-on image to ex- tract different features of the image. This paper provides the idea which is used to detect the affected area of the Vitiligo disease with help of image captured by camera and classified the affected area from non-affected area in image. Vitiligo is the deep-rooted skin disease which is depigmentation of the skin in which human skin starts losing or loss of pigment from the skin. The certain portion of the skin of body became white patches. The Vitiligo is visible in dark skin persons because of some genetic problem or environmental issues. Here, the learning vector quantization neural network is used to classify Vitiligo image in affected vs. non-affected region to detect disease.

2.7 Analysis and Classification of Human Skin Diseases

Most common skin diseases like skin cancers, leprosy etc are untreated and mostly causes death. Skin cancer has more cure rate if detected and treated early. The basic means of detecting these skin diseases is through visual inspection followed by biopsy and pathological examination. If the physician finds the appearance of lesion doubtful then normally visual inspection method is used for diagnosis but all malignant lesions are not identified through visual inspection. Now, there are no generally accepted tools that physician can use to immediately find the skin disease in the clinic. Most form of visual inspection could help to prevent misdiagnosis of BCC and other types of skin diseases. Previous work suggests that electrical impedance may distinguish skin cancer from other tissue. The electrical impedance of a tissue depends on its structural characteristics as well as its chemical composition. Studies have shown a wide degree of variation in the bio-electric properties between tissue and cells of body. The studies have shown differences in the electrical impedance of the skin as a result of irritation, allergic reaction, location, sex, age and hydration. A clinical study has also shown significant differences between affected skin and normal skin. Such clinical study is known as impedance measurement and based on a comparison of four indexes: magnitude, phase, real part and imaginary part index.

2.8 Image Analysis Model for Skin Disease Detection: Frame- work

Skin disease is the most common disease in the world. The diagnosis of the skin disease re- quires a high level of expertise and accuracy for dermatologist, so computer aided skin disease diagnosis model is proposed to provide more objective and reliable solution. Many researches were done to help detect skin diseases like skin cancer and tumor skin. But the accurate recognition of the disease is extremely challenging due to the following reasons: low contrast between lesions and skin, visual similarity between Disease and non-Disease area, etc. This paper aims to detect skin disease from the skin image and to analyze this image by applying filter to remove noise or unwanted things, convert the image to grey to help in the processing and get the useful information. This help to give evidence for any type of skin disease and illustrate emergency orientation.

Problem Definition: The early detection of skin diseases is very important as skin is one of the largest organ in the human body. Prevention of diseases and early diagnosis is of prime importance in today's scenario as the lifestyle has changed. Today's lifestyle has paved way to new diseases. Without proper care and safety, it may result in leading to chronic diseases. There is a need of system that can diagnose the skin diseases without any extensive tests being conducted.

III. METHODOLOGY

3.1 Depth wise Separable Convolution

A depth wise separable convolution benefits from the same characteristic as spatially separable convolutions, being that splitting the kernels into two smaller ones yields the same result with fewer multiplications, but does so differently. Effectively, two operations are performed in depth wise separable convolutions – sequentially:

3.2 Depth wise convolutions

As we've seen above, normal convolutions over volumes convolve over the entire volume, i.e. over all the channels at once, producing a WidthxHeightx1 volume for every kernel. Using N kernels therefore produces a Widthx HeightxN volume called the feature map. In depth wise separable convolutions, particularly the first operation – the depth wise convolution – this does not happen in that way. Rather, each channel is considered separately, and one filter per channel is convolved over that channel only.

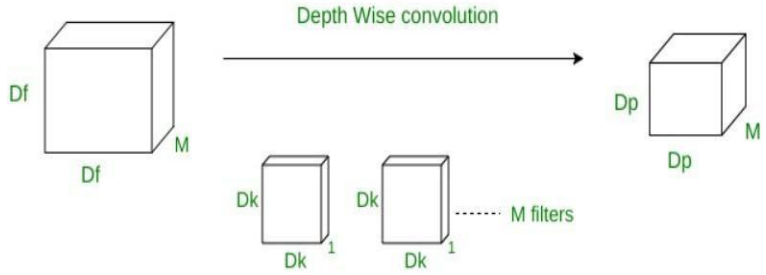


FIGURE 11: Depth Wise Convolution

3.3 Pointwise convolutions

From the intermediate result onwards, we can then continue with what are called pointwise convolutions. Those are filters of 11 pixels but which cover all the M intermediate channels generated by the filters, in our case M=3. And since we're trying to equal the original convolution, we need N of them. Remember that a convolution over a volume produces a Some Width x Some Height x 1 volume, as the element-wise multiplications performed over three dimensions result in a one-dimensional scalar value. If we would thus apply one such pointwise filter, we would end up with a Hfm x Wfm x 1 volume. As the original convolution produced a Hfm x Wfm x N volume, we need N such pointwise filters.

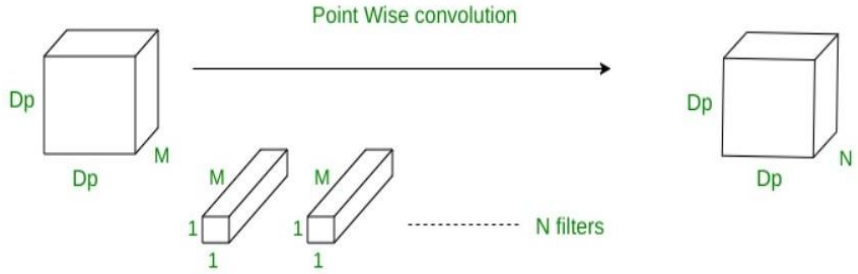


FIGURE 12: PointWise Convolution

3.4 Mobile Net

Mobile Net is a CNN architecture model for Image Classification and Mobile Vision. There are other models as well but what makes Mobile Net special that it very less computation power to run or apply transfer learning to. This makes it a perfect fit for Mobile devices, embedded systems and computers without GPU or low computational efficiency with compromising significantly with the accuracy of the results. It is also best suited for web browsers as browsers have limitation over computation, graphic processing and storage.

IV. IMPLEMENTATION

The proposed system uses convolutional neural network. The user gives input of the skin disease which the system processes, does feature extraction using CNN algorithm and use soft- max classifier to diagnose the disease. If no disease is found, the system produces a negative result meaning not in the dataset. The architecture contains two major parts feature extraction unit and classification unit. Feature extraction unit will enhance the image by removing noise and unwanted parts of the skin. Initially the images are pre-processed and converted to a standard size. Then the image is given as an input to the first layer of the network. Convolutional Neural Network is applied onto it until high-level features such as colour, shape and texture are obtained from it. Basically, the system consists of two modules:

- Feature Extraction Module
- Classifier Module.

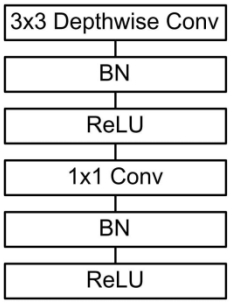


FIGURE 13: Architecture of the system

4.1 Feature Extraction Module

The module consists of performing operations like convolution, max pooling and ReLu. Based on the requirements, this layer may extend. The objective of the convolution operation is to extract the high-level features such as shape and texture, from the input image. Max Pooling returns the maximum value from the image covered by the Kernel. Max Pooling also performs as a Noise Suppressant. It removes the noises and also performs de-noising along with dimensionality reduction. ReLU is an activation function that has strong biological and mathematical operations.

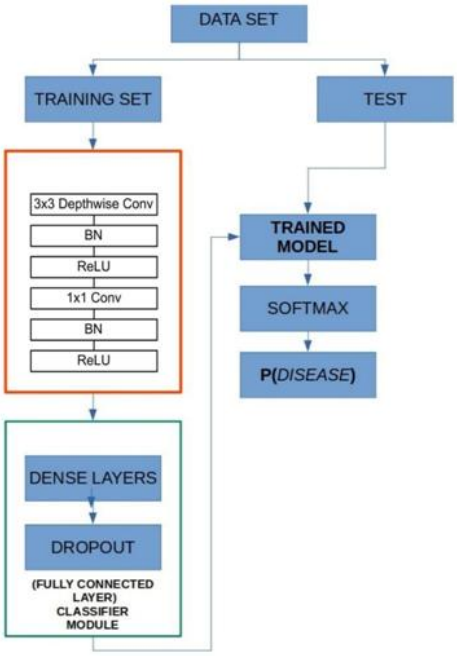
4.2 Classifier Module

The module consists of dense layer, dropout layer and softmax layer. Dropout layer is a technique used to improve over-fit on neural networks. During prediction, the dropout layer is deactivated. Dense layer is followed by a non-linear activation. The system can be broadly categorized into following major phases: Pre-processing the images, testing and training.

4.3 Phases of the system

Pre-processing phase: This phase includes image acquisition and pre-processing. In image acquisition, the images are acquired either through camera or through locally stored device. A high-quality image is required for the system implementation.

Testing and training phase: It includes data storage and classifier unit. The Data storage component is used to maintain testing and training data images. Training dataset is required for supervised learning. Testing dataset is the images acquired during image acquisition. The classifier identifies the type of skin disease. Softmax classifier used here is the last layer of the network that yields actual probability of each label.



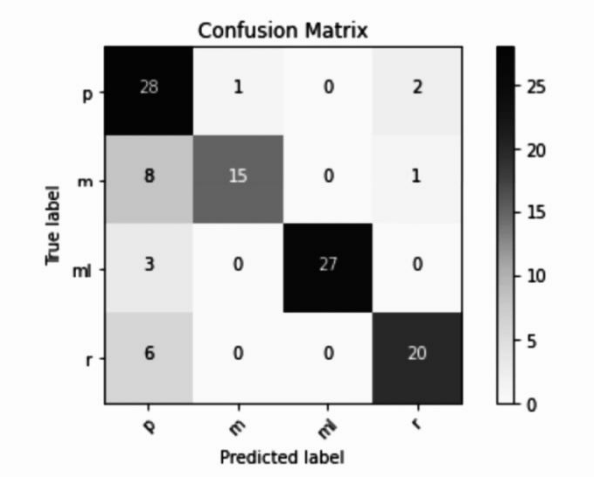


FIGURE 14: Mobile Net Data Flow Diagram

The system utilizes the Mobile Net architecture. The neural network learns and extracts the features by itself. Hence unlike image processing techniques used in the related works, feature extraction is done using depth wise separable convolution. Based on the training and validation data an accuracy of 98.38 is obtained. Initially with 2000 data samples, the system recognizes 4 diseases like ringworm, measles, psoriasis, and melanoma. The use of Mobile Net architecture has enabled us to create a light weight model which can be easily used on devices with even lower specs. We hope that our model is useful in the field of skin disease detection.

V. CONCLUSION & FUTURE WORK

The stated objective of the project is satisfied by the proposed design. After having carefully analyzed multiple papers and evaluating their pros and cons, we were able to design a neural network-based system for diagnosing skin diseases. In the system, methods which are being used to detect skin diseases exhibit better results and accuracy. The system enables the users to know what skin disease he is suffering from. This makes it possible for the users to take preventive measures to control the spreading of diseases and prevention at an early stage. Neural networks have many applications in medical field that help in early diagnosis and prevention of diseases. Convolutional Neural Networks have proved that large number of datasets can be trained within a short span of time and provide greater accuracy. Using advanced computational techniques and large dataset, the system can match the results of a dermatologist thus improving the quality standards in the area of medicine and research.

With vast dataset, the system could recognize diseases apart from those mentioned in the work. The real time application of the above work with an android platform could help the people to analyze the disease with a fraction of seconds. The remedial measures and location of the nearby dermatologist could also be included.

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