Digital Dermatology

Skin Disease Detection Model using Image Processing

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Abstract—**This paper proposes a skin disease detection method based on image processing techniques. This method is mobile based and hence very accessible even in remote areas and it is completely noninvasive to patient's skin. The patient provides an image of the infected area of the skin as an input to the prototype. Image processing techniques are performed on this image and the detected disease is displayed at the output. The proposed system is highly beneficial in rural areas where access to dermatologists is limited.**

Keywords—DCT, DWT, SVD, Image Processing

I. INTRODUCTION

Skin disease is an abnormal condition of the skin. Skin plays an important role in protecting the body from harmful bacterial, fungal and parasitic infections. Hence the correct diagnosis of skin disease is crucial. Various factors causing skin diseases and affecting skin disorder pattern are genetics, occupation, nutrition, habits, etc. Geographical factors like season and climate also affect. In developing countries, overcrowding and poor hygiene are responsible for spreading of skin diseases. The pattern of skin diseases varies from country to country. Moreover, remote areas are severely affected [1].

The prevalence of skin diseases in a tertiary care center of Garhwali hills, North India was recorded in 2014 and it was found to vary from 6.3% to 11.2%. Of the total population, 16.7% were affected by acne, 3.4% by psoriasis, 3.4% by urticaria, 3.6% by melasma and 3.3% by vitiligo [2].

In this paper, image processing is used to detect skin diseases in humans. This paper describes the current methods employed for detecting skin diseases, proposes a digital method to detect skin diseases and states the benefits of this method. This paper also includes a detailed description of the transforms used to implement the proposed method. The transforms implemented are compared on accuracy parameter.

II. LITEARTURE REVIEW

WHO (World Health Organization) has emphasized the severity of skin diseases in India which accounts for 10 to 12 percent of India's population. There are only 6000 dermatologists present to cater to a population of 121 crore people [3] and most of these dermatologists are concentrated in the cities. Due to this, rural areas are lacking dermatologists.

The current practices used by dermatologists include biopsy, scrapings, diascopy, patch testing and prick Test which are invasive methods of detection. In patch testing and prick test, the allergen is directly applied to the infected area. The skin might take a long time even several days to react to the allergen [4].

There are also certain disadvantages of the current image processing techniques used for skin disease detection. The main problem with the median filter is its high computational cost. Also, the software implementation of median filter does not provide accurate results [5]. The issue with sharpening filter is that when a high pass mask is applied to the image, there are negative pixel values in the output image.

III. PROPOSED SOLUTION

The proposed solution in this paper is a prototype with a database of six common skin diseases, using which a patient can self-diagnose and get some prior knowledge of their skin disease before consulting a dermatologist. This prototype can be used in mobile hospitals in rural areas. These days everybody is connected through mobile phones. Thus, this prototype can be accessed even in the most remote locations in the country.

The proposed prototype provides a noninvasive method of skin disease detection where the patient provides a picture of the infected area as an input to the prototype and any further analysis is done on this input image. No pricking or prodding of the skin is required.

A. Block Diagram

As can be seen from the two block diagrams, the proposed system consists of two processes: Training and Testing. Training process analyses and performs image processing on the training database whereas the testing process analyses the input image provided by the patient. Before any analysis on the input image is done, image pre-processing is done so that all images are consistent in desired characteristics. Resolution matching is done on the image so that they are all the same size (128x128). 128x128 is chosen so that the processing time is less. Fig. 1 shows the process of database creation.

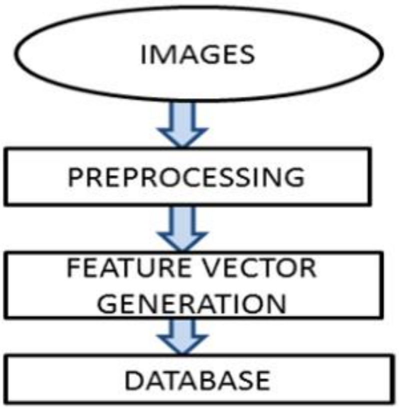

Fig.1. Block Diagram for Database Creation

In the training process, the training database first undergoes pre-processing and then its feature vectors are generated.

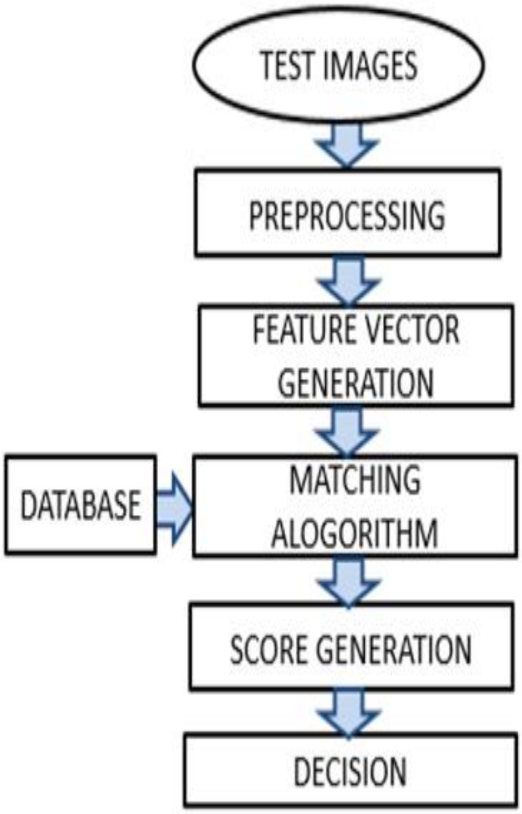

Fig.2. Block Diagram for Testing Process

As can be seen from Fig. 2, the testing process consists of an image provided by the patient which undergoes pre-processing and its feature vectors are generated.

Since this is an object query recognition application, the feature vectors of the two processes are compared and are classified by a matching algorithm.

B. *Diseases being Considered*

According to dermatologists, the ten most common skin diseases in India are eczema, psoriasis, acne, warts, vitiligo, tinea corporis, scabies, hives, rosacea and shingles [6]. Out of these, the six diseases considered for creating the database are: warts, tinea corporis, acne, vitiligo, nail psoriasis and eczema. Fig. 3,4,5,6,7 and 8 depict the above mentioned six diseases respectively.

Fig. 3. Warts

Fig. 4. Tinea Corporis

Fig. 5. Acne

Fig. 6. Vitiligo

Fig. 7. Nail Psoriasis

Fig. 8. Eczema

80 percent of people have had acne at some point in their life. Eczema being a long-term skin disease needs early diagnosis and constant care. Global warming, pollution and ultraviolet rays contribute to the increase of skin diseases.

IV. IMPLEMENTATION

The proposed solution is implemented using the following three transforms-

A. Discrete Cosine Transform [7-8]

Discrete Cosine Transform (DCT) transforms a signal or an image from spatial domain to frequency domain. In case of images, it separates the image into parts (or spectral sub-bands) of differing importance. The general equation for a 2-Dimension (2D) image with N rows and M columns is-

$$F(u,v) = \left(\sqrt{\frac{2}{N}}\right)\left(\sqrt{\frac{2}{M}}\right)\sum_{i=0}^{(2/N)-1} A(i) \sum_{j=0}^{(2/M)-1} A(j) \cos\left(\frac{\pi 4}{2N}(2i+1)\right)\cos\left(\frac{\pi 4}{2M}(2j+1)\right) f(i,j) \tag{1}$$

Where,

$$\Lambda(\xi) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for}\, \xi = 0 \\ 1 & \text{otherwise} \end{cases}$$

F (u, v) = DCT transformed image

f (i, j) = Original Image

In DCT transformed image, most of the visually significant information about the image is concentrated in the upper left corner of a 2D matrix i.e. few DCT coefficients. Hence, the feature vector of a DCT transformed image is generated by zigzag scanning which is represented by Fig. 9. Energy compaction property of DCT is used here.

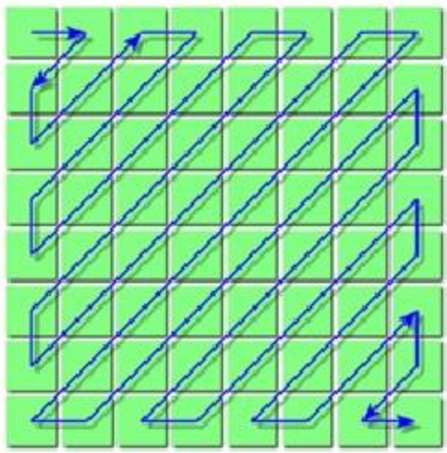

Fig. 9. Zigzag Scanning in DCT

B. Discrete Wavelet Transform [9-12]

Wavelet transform has become a powerful statistical tool in signal processing, data compression, fingerprint verification, speech recognition and in finance as well, for detecting the properties of quick verification values. Wavelet transform is based on wavelets. Wavelets have zero mean and they exist for finite duration. These wavelets hierarchically decompose functions in the frequency domain as well as preserve the spatial domain. Discrete Wavelet Transform (DWT) decomposes the signal into mutually orthogonal set of wavelets. It treats images as 2-D signals and hence 2-D DWT is applied to images. DWT provides frequency components information as well as indicates these components' time of occurrence. Separability property can be used to implement 2D- DWT. 2D-DWT can be performed by implementing 1D-DWT along the rows followed by 1D-DWT along the columns. The filter bank representation of this method is shown in Fig. 10.

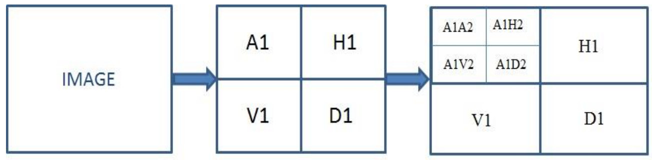

Fig. 10. DWT Transform when applied on an image

Thus, the 2D signal is divided into four sub-bands:

LL – This quadrant contains all coefficients obtained after low pass filtering along the rows followed by low pass filtering along the columns. This upper left quadrant represents the approximated version of the original image at half the resolution. Hence this sub-band is also called as approximation sub-band.

HL – This quadrant contains coefficients obtained after high pass filtering along the rows followed by low pass filtering along the columns. This upper right quadrant represents the horizontal edges of the original image.

LH – This quadrant contains coefficients obtained after low pass filtering along the rows followed by high pass filtering along the columns. This lower left quadrant represents the vertical edges of the original image.

HH – This quadrant contains all coefficients obtained after high pass filtering along the rows followed by high pass filtering along the columns. This lower right quadrant represents the diagonal edges of the original image.

As mentioned above, that wavelet transform hierarchically decomposes the signal; the decomposition can be of level 1, level 2 or level n decomposition depending on the application.

Fig. 11. Original Image [13]

Fig. 11 shows a pre-processed image. After level 1 decomposition of the image, approximation and detail (horizontal (H), vertical (V) and diagonal (D)) coefficients are obtained which is represented by Fig. 12.

In this paper, the images are decomposed using DWT of db4 type into number of levels for comparative analysis. The approximation coefficients are the features of the decomposed image, which are later used to detect a disease.

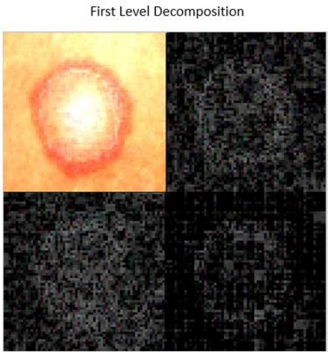

Fig.12. DWT Transform applied on Input Image when L=1

C. *Singular Value Decomposition [14]*

Singular value decomposition (SVD) plays an important role in linear algebra. It is used for computing pseudorandom of a matrix, solving a set of homogenous linear equations, decomposing a matrix into weighted, ordered sum of separable matrices and in Kabsch algorithm to compute optimal rotation. In addition to these applications, it is also applied to signal processing, in numerical weather forecast to generate ensemble forecast and in recommender systems to predict people's item ratings.

Singular value decomposition factorizes a real or complex matrix. Singular value decomposition of a matrix A with m rows and n columns with m>n is a factorization of the form-

$$A = U\sum V^T \tag{2}$$

where,

U – m × m real or complex unitary matrix.

∑ – m × n rectangular diagonal matrix with nonnegative real diagonal numbers

V – n × n real or complex unitary matrix.

U and V are orthogonal matrices. The diagonal entries of ∑ are called singular values of A. The columns of matrices U and V are called left-singular vectors and right-singular vectors of A respectively.

In image processing, singular values are used to reconstruct an image that is closer to the original image, as shown in Fig. 13. The number of singular values used determines the clarity of an image. Since the maximum signal energy is found in few coefficients, only those coefficients are used, which in turn reduces the size required to store an image.

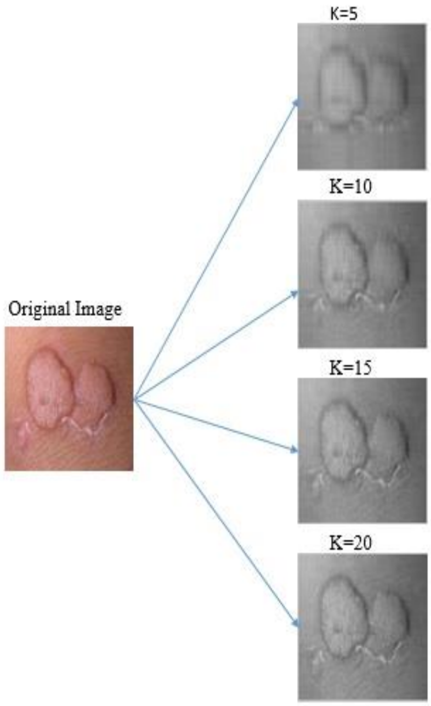

Fig. 13. SVD Transform on Original Image for k=5, 10, 15, 20

In this paper, the feature vector of SVD reconstructed image is generated with the help of singular values.

V. RESULT ANALYSIS

The diseases were first detected using DCT with 8, 16, 32 and 64 coefficients. DWT with different levels of decomposition and SVD with different number of singular values were also implemented to detect diseases [1].

In a DCT transformed image, the most significant coefficients are concentrated in the upper left corner of the image while the lower right corner is concentrated with least significant coefficients. When 8 DCT coefficients are considered, then Euclidean distance between 8 coefficients of the image to be tested and 8 coefficients of the training image is computed. Similar process is followed when 16 DCT coefficients are considered. But when the same is followed with 32 and 64 DCT coefficients then the least significant coefficients i.e. the high frequency components are also included in the computation. These high frequency components are mostly redundant coefficients i.e. they are highly correlated with upper left corner coefficients; hence they do not contain any extra information and thus for this reason they either contribute less or not at all to the computation. Thus, as observed from Fig. 14, the accuracy of correct disease detection is highest for 16 DCT coefficients, equal for 8 and 32 DCT coefficients and decreases for 64 DCT coefficients.

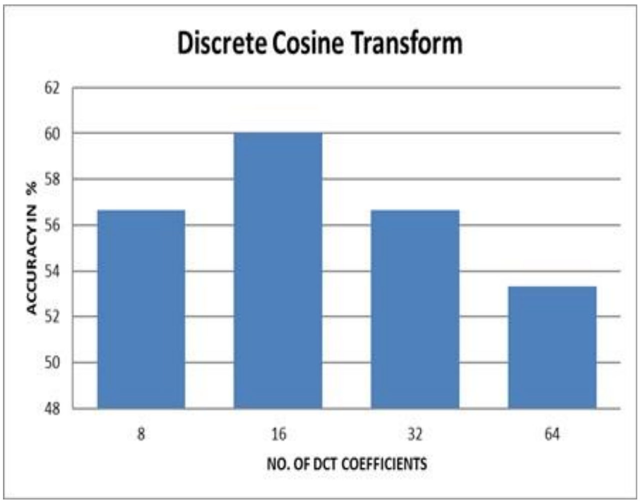

Fig. 14. Accuracy of detection for different coefficients in DCT

In DWT transformed image, the image is divided into approximation and detailed coefficients with approximation coefficients containing most of the image information. Therefore, Euclidean distance between approximation coefficients of the image to be tested and training image is computed. As the level of decomposition increases the approximation coefficients considered for computation decreases. Thus, as observed from Fig. 15, highest accuracy of correct disease detection is obtained for level 1 and the detection rate decreases with increase in level of decomposition.

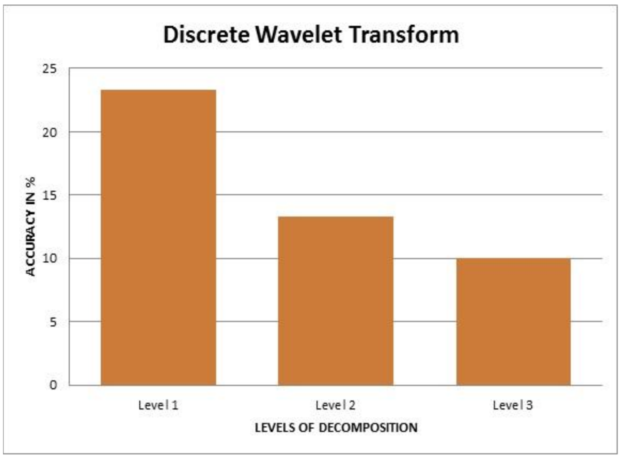

Fig. 15. Accuracy of detection for different levels in DWT

In SVD transform, singular values contain most of the image information and for this reason the image is reconstructed with singular values. In this paper, the image is reconstructed with 5, 10, 15, 20, 25 and 30 singular values. With 30 singular values, the reconstructed image resembles the original image. The Euclidean distance between reconstructed tested image and reconstructed training image is computed. As observed from Fig. 16, the accuracy of correct disease detection is same for all singular values. But this is the only transform that detects acne. Hence this transform is also used for disease detection.

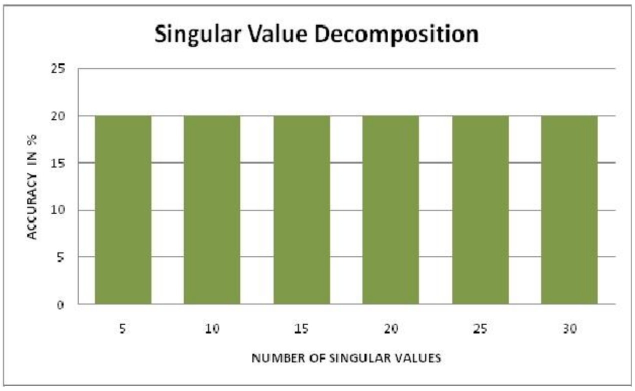

Fig. 16. Accuracy of detection for different singular values in SVD

To achieve higher accuracy, all the three transforms were combined and then disease detection was performed. As observed from Fig. 17, highest accuracy of correct disease detection is obtained for combination of three transforms.

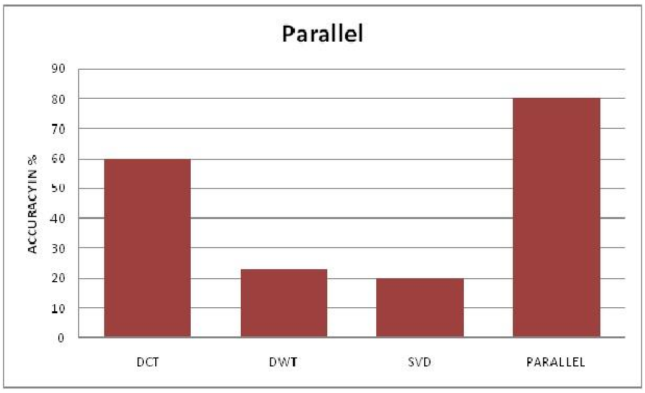

Fig. 17. Accuracy of detection for different transforms

VI. CONCLUSION

The proposed system was implemented in MATLAB version 7.12.0 on a Windows 10 64-bit operating system with Intel(R) Core(TM) i3-6100U CPU @ 2.30GHz processor.

Skin Diseases being extremely common must be detected at the earliest stage. The proposed system in this paper provides a feasible solution for skin disease detection providing up to 80% efficiency. The average training time for the three transforms and the parallel combination was found to be 2.066 seconds. And the average testing time was found to be 0.7866 seconds.

This paper gives the description, result analysis and comparison of the efficiency between the three transforms DCT, DWT and SVD. From implementation of the proposed system, we can conclude that the parallel combination of the three transforms provides the maximum and efficient detection as can be seen from Fig. 17. With the exclusion of SVD transform from the proposed system, it can be used as a basic prototype to pave way for faster diagnosis of skin diseases.

VII. FUTURE SCOPE

The proposed prototype consists of six diseases. For commercial viability, the prototype must have a database that includes most skin diseases with pictures of all skin tones and types. This would lead to efficient and accurate detection.

Currently the prototype is an offline application. This prototype can be enhanced by connecting it online to provide immediate online access to dermatologist after initial detection. This further decreases the buffer time before the patient can reach the dermatologist. It can further be improved by providing precautions and immediate relief measures which the patient can follow so as to take care not to aggravate the disease.

The proposed prototype can be modified to detect Basal and Squamous Skin Cancer Stages.

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