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A Reliable Approach to Access Psoriasis Severity from Psoriasis Images

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***Abstract* - Image processing has become a critical component in contemporary science and technology such that many tasks would not be attempted without it. It has applications in medical imaging, microscopy, astronomy, computer vision, geology and many other fields. Now days it finds wide application in diagnosis of psoriasis, which is a skin disease. Psoriasis is a dermatological disease characterized by red, thickened areas with silvery scales. It can present in various patterns and forms. Treatments are provided based on accessing the psoriasis severity. To access severity scaling present in involved area is considered. Currently psoriasis treatments are provided based on developing a visual score. However, these scores are strongly dependent of doctor. Different doctors can have variations in these scores and hence treatments provided will be different for the same psoriatic lesion. In this situation a reliable method to access degree of scaling is needed for better treatment. There are cases where other skin diseases are also misconsidered as psoriasis. So, an initial identification purpose is required to know whether input image is psoriasis image or not. A reliable evaluation method for psoriasis with efficient feature extraction is presented in this paper. The method extract texture features from images using log Gabor filter. Initially features are extracted from psoriasis images and non psoriasis images. These features are used to train neural network classifier. If an input image is given, it will identify whether it is psoriasis image or not. Then it is further segmented to access degree of scaling from images.**

***Keywords*:- Erythema, scales, feature extraction, image segmentation**

1. INTRODUCTION

It is estimated that approximately 2% of the US population is affected by psoriasis. Similar prevalence values have been obtained in Europe, with the exception of slightly higher values seen in Norway and the Faeroe islands. Males and females are affected equally. Psoriasis is a chronic inflammatory disorder of the skin that can affect a person at any age, but most commonly presents in bimodal peaks between the ages of 15 and 30, and after 40 years of age [2]. It is characterized by red, thickened areas with silvery scales. The scale is silvery white and reveals bleeding points when removed. Scaling results from an enhanced rate of epidermal cell production manifesting anywhere from a few spots to a large area of plaque, typically found on erythema, or red inflamed skin. Psoriasis is considered to be hereditary, but environmental circumstances such as streptococcus infections, stress and some drugs may trigger the disease. Furthermore, stress associated with psoriasis can influence physical health. Severity of disease varies from person to person. It can be mild, moderate or highly severe. A patient with moderate to highly severe psoriasis needs regular treatment. Psoriasis is considered to be probably a disorder of immune system, even though exact reason is unknown. The immune system includes special blood cells that identify and destroy foreign material including viruses and bacteria. These are called white blood cells. There are 2 types of white blood cells: T cells and B cells. When T-cells identify a foreign material they attack it. Psoriasis causes abnormal immune system activity of T-cells in the skin. These T-cells cause the skin to become inflamed and reproduce excessively. Normal skin cells are replaced every 3-5 days in psoriasis rather than usual 28-30 days. These extra skin cells form thick, dry, silvery scales and red patches.

The disease is transmitted genetically, most likely with a dominant mode with variable penetrance and the origin is unknown. The disease is lifelong and characterized by chronic recurrent exacerbations and remissions that are emotionally and physically debilitating [4]. Primary cause of psoriasis is unknown. Hence, it is not yet possible to prevent it completely. But, when small plaques are treated at initial stage itself, it is possible to prevent serious outbreaks. There is no cure for psoriasis, but there are different treatments to suppress its symptoms. The primary goal of treatment is to stop skin cells from growing so quickly. However, any treatment of psoriasis is based on its initial assessment of severity. To measure severity, scaling present in involved area is considered. Severity of psoriasis varies greatly from people to people. In some people, it is just a minor irritation, for some others it may have a major impact on their quality of life. Thus severity can be mild, moderate or major. Based on degree of severity, treatments provided will be different. Currently psoriasis treatments are provided based on developing a visual score. However, these scores are strongly dependent of doctor. Different doctors can have variations in these scores and hence treatments provided will be different for the same psoriatic lesion. So, to avoid patient's risk of having false treatment, a reliable approach to access degree of scaling from psoriasis images is needed. By using computer aided diagnosis utilizing image processing techniques, patient care can be extended even to remote areas

In this paper, an automatic method for accessing psoriasis severity is proposed. It initially identifies whether

input image is a psoriasis image or not. If it is a psoriasis image, segmentation of scaling is performed.

2. PROPOSED METHOD

Psoriasis is characterized by white colored scales along with reddish inflammation. White colored part is called scaling and red colored inflamed part is called erythema. When scaling appears as small spots or when scaling is scattered within erythema, it is hard to distinguish scaling and erythema. It becomes quite easier to differentiate, when color difference between scaling and erythema is high. In order to differentiate scaling from skin, texture features are considered.

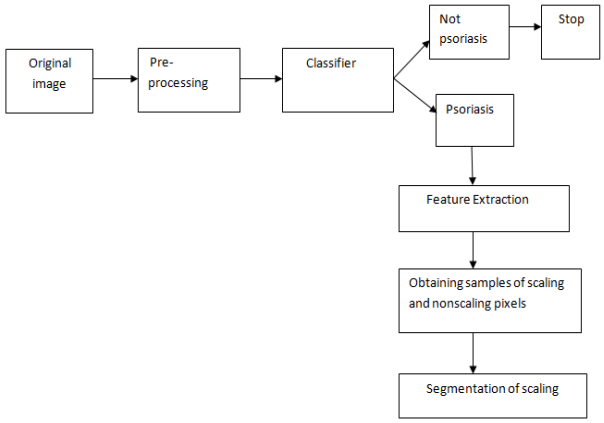


Fig1. Flow chart of algorithm for segmentation of scaling

From the original image, scaling features are extracted by considering color. Then, neural network is trained with a set of psoriasis and non psoriasis images using these extracted features. So, if an input image is given, it will compare its features and will give an output indicating whether input is psoriasis image or not. If input image is not psoriasis, further processing is not done. If it is a psoriasis image, then features are extracted from image for segmentation. For better segmentation, features from color and texture are extracted. Features are extracted from color using scaling contrast map and from texture using log Gabor filters. Then samples of scaling and non scaling pixels are collected. Using these samples segmentation is performed.

Collection of samples proceeds by first removing erythema and other dark pixels from image. Then, location of erythema is identified in the original image. Using erythema removed image and erythema located image, samples of scaling and non scaling pixels are collected based on the fact that scaling is often or partially surrounded by erythema. Then, segmentation is performed using soft constrained k means clustering.

2.1. Preprocessing

Image pre-processing aims at enhancing data images prior to computational processing. Here preprocessing is done to extract color features from images. Psoriasis is mainly characterized as white scales along with reddish inflammation. But most of the skin disease suffers with red rashes on skin. Hence to differentiate psoriasis from other diseases, features extracted from color is used. When scaling is scattered within erythema, it is hard to discern visually. To enhance the contrast of scaling in such situations a scaling contrast map is developed. L*a*b* color space is used to develop a pair of multi-scale center-surround filters that increase the contrast between scaling and erythema. The L*a*b* color space is a color representation technique which consists of luminosity layer L*, chromaticity layers a* and b*.

Contrast of scaling is increased using scaling contrast map. A scaling contrast map can be defined as,

$$S_{x,y} = J\left(L^*_{x,y}\right) + J\left(inv\left(a^*_{x,y}\right)\right) \qquad (1)$$

J(.) is a multi-scale center-surround filter that detects contrast and inv(a*) inverts the image in the a* dimension. The multi-scale center-surround filter J(.) is defined by,

$$J\left(X_{x,y}\right) = \sum_{s=1}^{3} X_{x,y} - \frac{1}{N} \sum_{\substack{x-w(s)\le m\le x+w(s) \\ y-w(s)\le n\le y+w(s)}} X_{m,n} \qquad (2)$$

Where s is the scale. The scale determines the window size, w and N is the number of pixels in window. The contrast filter J(.) is computed for both L image and inverted(a*)image. Then, they are added together to obtain final scaling contrast map. For scaling, L* value is 100, hence scaling contrast map will be very high for scaling pixels. For erythema, a* value is positive. Since we are inverting the a* dimension, scaling contrast map will be very low which will be negative for erythema pixels. Skin pixels also possess low value of scaling contrast map, but usually higher than erythema pixels.

2.2. Classifier

Gradient descent back propagation neural network is used as classifier. Here features extracted using scaling contrast map from set of images which are psoriasis and non psoriasis are used to train network. Back propagation is a multilayer feed forward supervised learning network based on gradient descent learning rule. It provides a computationally efficient method for changing weights in the feed forward network with differentiable activation function units to learn a training set of input-output data. Being a gradient descent method, it minimizes the total squared error of the output computed by the net. The aim is to train the network to achieve a balance between the ability to respond correctly to the input patterns that are used for training and the ability to provide good response to the input that are similar. traingdx is a network training function that updates weight and bias values according to gradient descent momentum and an adaptive learning rate. Gradient of error means derivative of error with respect to weight. This method requires computation of the gradient of error function at each iteration step. Activation function are needed for hidden layer of the neural network to introduce non linearity. Sigmoid activation function is usually used for

hidden layer. Back propagation is used to calculate derivatives of performance with respect to the weight. Training stops when any of these conditions occurs:

a) Maximum number of repetitions is reached.
b) The maximum amount of time is exceeded.
c) When performance is minimized to the goal.

After training when input image is given, it will identify whether image is psoriasis image or not. If it is a psoriasis image, segmentation is performed. Else, it is not processed further.

2.3. Feature space for detecting scaling

Features of scaling extracted from color and texture is used for segmentation of scaling from images. Features from color are extracted using scaling contrast map. Features from textures are extracted using log Gabor filter.

2.3.1 Scaling Contrast Map

Color features extracted using scaling contrast map during preprocessing step is used for segmentation of scaling from psoriasis images.

2.3.2 Texture analysis with log Gabor filters

Texture analysis is often used in segmenting an image into uniformly textured regions or locating the borders between different textures. Using only the RGB intensities as features the scaling is almost indistinguishable from light normal skin. To overcome this problem log Gabor filters are introduced to pick up the texture of the scaling. In particular, Gabor filters were mostly used for feature extraction from texture. But, it suffers with certain drawbacks. Hence log Gabor filters are used here. They overcome the drawbacks of Gabor filter in such a way that, Log Gabor filters are designed as Gaussian functions on log axis. Their symmetry on log axis result in more effective representation of uneven frequency content of images. Hence, redundancy in lower frequency is reduced. Log Gabor filters do not have dc component. So, bandwidth is not limited, but is increased. Hence only fewer filters are required for wide spectrum coverage.
The frequency response of log-Gabor filters in polar coordinates is given by,

$$LG_{m,n}(f,\theta) = \begin{cases} exp\left\{-\frac{\left(log\left(f/F_m\right)\right)^2}{2(log\,\beta)^2}\right\} exp\left\{\frac{-(\theta-\theta_n)^2}{2\sigma_\theta{}^2}\right\} & ; f \neq 0 \\ 0 & ;\ f = 0 \end{cases} \quad (3)$$

Its corresponding representation in log axis is given by,

$$LG_{m,n}(\rho,\theta) = \begin{cases} exp\left\{-\frac{(\rho-\rho_m)^2}{2(\sigma_\rho)^2}\right\} exp\left\{\frac{-(\theta-\theta_n)^2}{2(\sigma_\theta)^2}\right\} & ; f \neq 0 \\ 0 & ;\ f = 0 \end{cases} \quad (4)$$

The entire process is summarized as,
a) Input image is transformed to frequency domain by taking Fourier transform.
b) Log Gabor filter frequency response is computed over different angle and frequency.
c) Response of log Gabor filter is obtained by taking convolution of filter with Fourier transformed image.
d) Filtered image in the input space is obtained by applying inverse Fourier transform to the convolved result.
e) Log Gabor energy is computed by taking norm of log Gabor filter response.
f) Final log Gabor texture image is obtained by summing filtered output over all angle and frequency.

The response is high when the image intensity frequency is close to the Gabor filter. For smooth normal skin the image intensity is relatively homogeneous and is not sensitive to Gabor filters. For rougher scaly skin, the change of intensity is relatively high. Scaling has a high Gabor filter response while normal skin has a markedly lower Gabor filter response.

2.4. Collection of samples of scaling and nonscaling pixels

Samples are collected for segmentation of scaling from psoriasis images. Collection of samples includes three steps: Removal of erythema, localization of erythema and obtaining samples of scaling and non scaling pixels.

2.4.1 Removing erythema and other dark pixels

Erythema and darker pixels possess lower value of scaling contrast map, because image is inverted in a* dimension to create contrast map. The scaling contrast map is applied to the image and the resulting image is processed to thresh-hold out all dark pixels representing darker pigments in the skin and including erythema, hair, moles, and other blemishes. Scaling and normal skin pixels remain in consideration after the application of the contrast map because they result in a significantly high value of S. Erythema removed image is defined as,

$$M_{x,y} = \begin{cases} 1, & if \quad S_{x,y} \geq t_s \\ 0, & otherwise \end{cases} \quad (5)$$

2.4.2 Localization of erythema

The location of erythema is identified by gray-scale intensity using the scaling contrast map S where low values of indicate red pixels. Erythema possesses negative values in scaling contrast map. Darkened normal skin would show negative values in the scaling contrast map, but would still

be greater than the values of erythema. A pixel is labeled to be erythema if,

$$S_{x,y} \leq 0.2\, min_{i,j}\, S_{i,j} \quad (6)$$

2.4.3 Obtaining samples of scaling and skin pixels

Scaling typically appears as white or creamy colored scales on regions of red and inflamed skin (erythema). Hence we use dilation and erosion operations to create regions of scaling enclosed by boundaries of erythema. Regions within the boundaries thus created are filled using a floodfill operation. Let M be the erythema removed image and X be the erythema located image, which is further dilated, floodfilled and eroded. Intersection of M with those regions that are bounded and floodfilled gives the location of scaling pixels. Non intersecting regions give the location of non scaling pixels.

2.5. Segmentation of scaling

A cluster of scaling pixels C1 and a cluster of skin pixels C2 are formed from union of samples of scaling and skin pixels. The centroids for each of the two clusters is defined by,

$$O_i = \frac{\sum_{(x,y)\in c_i} w(L_{x,y},C_i)\, F_{x,y}}{\sum_{(x,y)\in c_i} w(L_{x,y},C_i)} \quad (7)$$

W ($L_{x,y}$,C_i) is a weighting function for the location and class C_i.

$$W(L_{x,y}, C_i) = P(L_{x,y}, C_i)^{-1} \quad (8)$$

Probability is determined by the location of the scaling and the nonscaling. If Lx,y is in an approximate region that indicates the same class as C_i , a higher value is assigned, otherwise a lower value is assigned. Clustering is achieved by minimizing an objective function. The objective function for soft constrained k means is the sum of weighted distance of a sample to each of the cluster centroids.

$$h(c,o) = \sum_{i=1}^{2} \sum_{(x,y)\epsilon c_i} W(L_{x,y}, C_i) \|F_{x,y} - O_i\|^2 \quad (9)$$

Pixels which belong to class C_i are taken to be those samples in the image such that,

$$\frac{w(L_{x,y},C_i)\|F_{x,y}- O_i\|^2}{w(L_{x,y},C_j)\|F_{x,y}- O_j\|^2} \leq t_h \quad (10)$$

Pixels which belong to scaling are those which satisfies this equation for which i=1 and j=2. Similarly, nonscaling pixels are those which satisfies this equation for which i=2 and j=1.Thus segmentation is performed.

3. EXPERIMENTAL RESULTS

In this section, MATLAB simulation results of the proposed method are presented.

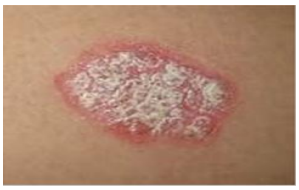


Fig 2. (a) Original image

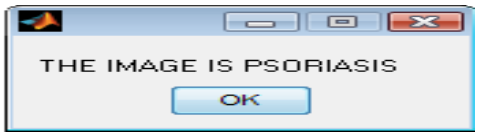


Fig 3. Neural network output indicating input image is psoriasis

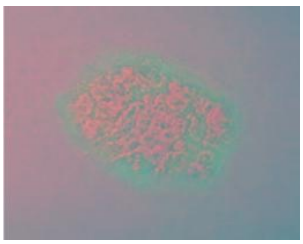


Fig 4. (a) Original image converted into L*a*b* color space.

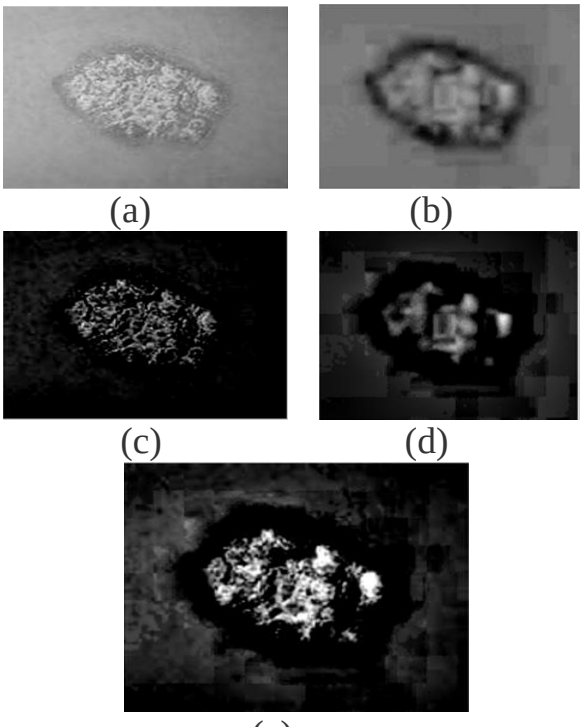
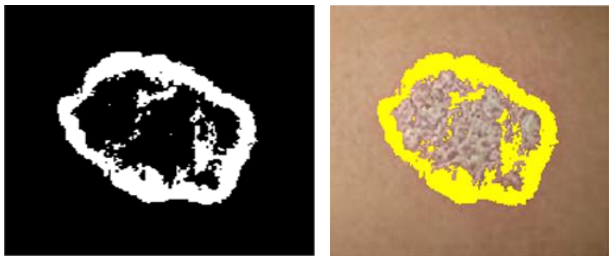


Fig 5. Scaling contrast map construction. (a) L* image (b) Inverted a* image (c) Contrast map derived from L* (d) Contrast map derived from a*. (e) Scaling contrast map

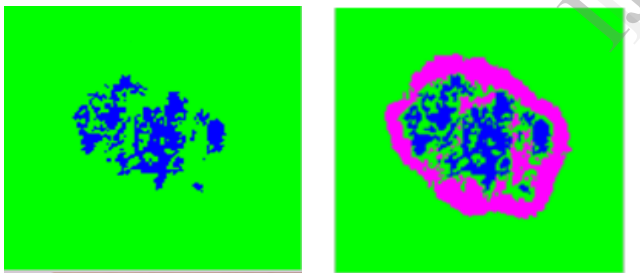
Fig 6. The final Log Gabor texture image.

Fig 7. Erythema and dark pixels removed image where white colored pixels are in matrix M.

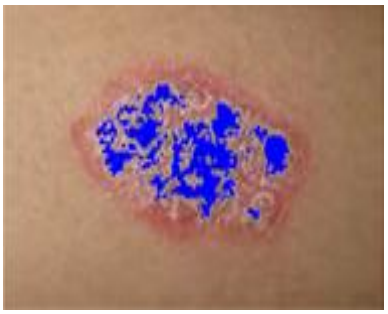


(a) (b)

Fig 8. (a) Approximate localization of erythema marked in white in scaling contrast map. (b) Approximate localization of erythema marked in yellow in original image.



(a) (b)



(c)

Fig 9. Segmentation of scaling.(a)Scaling pixels marked in blue and nonscaling pixels marked in green (b)Scaling marked in blue, normal skin marked in green and erythema located region marked in magenta.(c) Scaling of input image

Fig.2 shows the original image and fig.3 shows the neural network output for given image. Fig 4 shows Original image converted to L*a*b* color space for processing. Fig 5 shows different steps in constructing scaling contrast map. The color of scaling correlates well with higher values of L* and erythema with positive values of a*. Scaling contrast map is high for scaling pixels .Since image is inverted in a*dimension, erythema possess lower values in scaling contrast map. In fig 6, final log Gabor texture image is shown. Accurate segmentation occurs only if feature are extracted in an efficient manner. The algorithm uses a bank of 24 log Gabor filters defined over 6 different frequencies and 4 different orientations.

Threshold T_s = .004 for the scaling contrast map in the definition of $M_{x,y}$ as a balance between removing erythema and retaining scaling. Resultant erythema removed image is shown in fig.7. Threshold t_h is set to be .1, inorder to ensure that samples have a high likelihood of being within their respective pixel classes. Clustering output obtained for scaling and nonscaling pixels is marked in fig.9. Final segmentation output of scaling is given in fig 9 (c).

4. CONCLUSION

In this paper an automatic method for psoriasis image segmentation using soft constrained k means clustering which can be used in an evaluation system for treatment of psoriasis is proposed. Method initially checks whether input image is psoriasis or not using neural network as classifier. The feature space used in the classification is derived from the color contrast between scaling and erythema, and the image texture describing the roughness of scaling which is determined by the aggregated result from a bank of log Gabor filters. Since texture & color information are both taken into consideration, the segmentation is more robust than that produced by the method using only color information.

The use of the contrast map enables our algorithm to differentiate scaling from shadows, images captured in high illumination and images captured in low illumination. In addition, our algorithm shows robustness to wrinkles and skin with short hair. This is a contribution by the log Gabor features. The designed bank of log Gabor filters is good at characterizing the difference of scaling from wrinkles and short hair, due to the use of multiple scales and orientations.

Samples of scaling and nonscaling pixels are collected based on the fact that scaling is often or partially surrounded by erythema. Using these samples segmentation is performed. The proposed method shows an accuracy of 90%. It is reliable over existing method such that, Segmentation is performed only if input image is psoriasis. Also, it is efficient over existing method such that, features are extracted from texture using log Gabor filters.

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