A Comparative Analysis of Segmentation Techniques to Extract Skin Lesion Regions

A. Ranichitra, D. Seethalakshmi

Abstract: ***Skin diseases are the most common health problems in worldwide. Diagnosis of the skin disease depends on the extraction of the abnormal skin region. In this paper, Segmentation techniques to extract the skin lesion regions are proposed and their results are compared based on the statistical and texture properties. The acquired skin images are preprocessed by median filter and segmented by Edge-based segmentation, Morphological segmentation and K-means clustering techniques. The statistical features mean and standard deviation and the texture features contrast and energy are calculated for all the segmented skin lesion images. The performance of the three segmentation techniques are compared and found that the K-Means algorithm yields better results without any over and under segmentation.***

Index Terms: Edge Based Segmentation, energy, contrast, K-Means Clustering, Morphological segmentation, mean, standard deviation, skin lesion,

I. INTRODUCTION

Dermatology is the branch of medicine which deals with hair, nail and skin diseases. It has the specialty with both medical and surgical aspects. Human skin is one of the most unpredictable and difficult terrains to automatically synthesize and analyze due to its complexity of jaggedness, tone, presence of hair and other mitigating features [1]. Human skin is a difficult surface, with fine scale geometry that makes its appearance difficult to model. Melanin and hemoglobin pigments are contained in this structure. Slight changes of pigment construction in skin may cause rich variation in skin color. By analyzing the skin texture, a lot of observations can be made concerning the nature and coarseness of the skin. Skin diseases, if not treated earlier might lead to severe complications in the body including spreading of the infection from one individual to the other. So it is necessary to be cautious regarding skin care. Developing a system for classification of skin disease is a difficult task because of the considerable similarities among different classes and also due to a large intra-class variation. These problems will make confusion to split the classes and difficult to identify skin diseases [2].

Diagnosis of skin diseases depends on the appearance, texture, shape, color and sizes of the skin regions. Manual analysis is based on fixed visual quality inspection performed by human operators, which is time consuming, slow, non-consistent and costly. A cost effective, reliable and accurate detection of lesion area is possible by using machine vision. Image segmentation plays a vital role to extract the abnormal skin lesion regions. The features extracted from these regions are further used for the diagnosis of skin diseases. In this paper, three segmentation techniques Edge-based, Morphological and K-means clustering techniques are proposed to extract the abnormal skin regions and statistical and texture features are calculated for the classification of diseases.

This paper is organized into five sections. Section II provides the review of existing image segmentation and features extraction methods. The proposed segmentation techniques are discussed in Section III. Experimental results and analysis are made in Section IV and finally the conclusion and future direction of the work is given in Section V.

II. LITERATURE SURVEY

A literature review on various segmentation techniques to extract the skin regions and their properties are reviewed in this section.

Moureen Ahmed et al., proposed the techniques (Edge, Threshold, Texture, Color and K-means) for segmenting the lesion in mango fruit and to calculate the area of the lesion. Segmentation using K-means algorithm was found to be more precise in detection of lesion areas which will be more accurate and efficient [3].

Priyanka et al Psoriasis., proposed disease diagnostic system using artificial neural network which provides better accuracy and faster diagnosis than human physician. The color and texture features play an important role in classifying the particular disease [4].

Ashwini C et al., used GLCM (Gray-Level Co-Occurrence Matrix) technique to diagnose psoriases skin disease. This study relied on both skin color & texture features (features derives from the GLCM) to give more efficient and better recognition accuracy of skin diseases. Feed forward neural networks are used to classify the input images into Psoriasis affected skin and not [5].

Nishadevi Ret al., proposed a method for extracting the features (color & texture) of the Lesions to classify the lesion into benign, suspicious and melanoma [6].

Nidhal K et al., relied on skin color and texture features derived from GLCM) to give better and more efficient recognition accuracy of skin diseases [7].

From the review, it has been concluded that Edge-based Segmentation, Morphology-based segmentation and k-means Clustering Method will best perform in the extraction of skin lesion regions.

III. PROPOSED SEGMENTATION TECHNIQUES

Extraction of Skin Lesion region contains the following phases: Image Acquisition, Pre-Processing, skin Lesion Detection and Feature Extraction. The schematic diagram is shown in Fig.1

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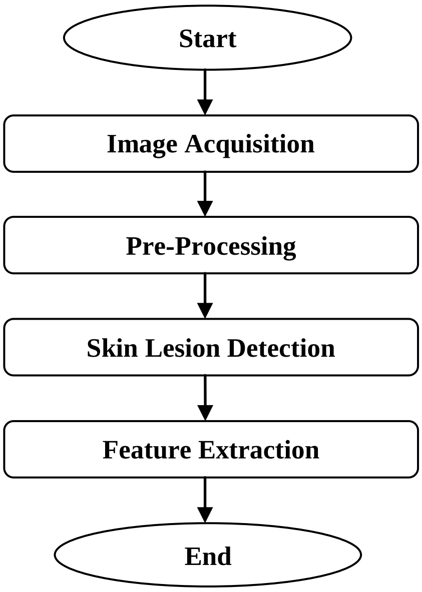

Fig.1 Schematic Diagram of the Proposed Method

A. Image Acquisition

Image acquisition is an initial step in any image processing system. The skin images are captured using a digital camera with resolution of 5MP and resized to 257×196 for faster computations. The acquired RGB image is read in MATLAB using the function *imread()*. The sample skin lesion image is shown in Fig. 2

Fig. 2 Skin Lesion Image

B. Pre-Processing

The input RGB skin lesion image is converted into a gray scale image by using *rgbtogray()* function so that the saturation and hue components are eliminated and only the luminance value is retained. During image acquisition, the input image may be corrupted by unwanted noise particles due to some illumination factors and that can be removed by applying the median filter. The preprocessed image is shown in Fig 3.

Fig. 3 Pre-Processed Image

C. Segmentation Techniques

After preprocessing, three segmentation techniques namely Edge-based Segmentation, Morphology-based segmentation and k-means Clustering are proposed to extract the abnormal skin lesion regions. The outputs of these Segmentation Methods are obtained and compared by calculating the features of the segmented skin lesion region.

Edge-based Segmentation

Edge detection is one of the most frequently used techniques in Digital Image Processing. The boundaries of the object surfaces in a scene will often lead to oriented localized changes in intensity of an image, called edges. Some of the existing edge detection operators are Sobel, Prewitt and Kirsch. In this work, to extract the affected area of the skin, Gradient Operator is used which is given below.

$$G = \frac{G_x}{G_y} \quad (1)$$

where G_x and G_Y represents the horizontal and vertical derivatives at a particular point..

The extracted boundary image is shown in Fig 4. The boundary of the segmented image (mask) is identified and inserted into the original image to highlight the affected skin area. The procedure for Edge Based Segmentation is given below:

Step 1: Input the preprocessed skin lesion image.
Step2: Apply Gradient Operator
Step3: Detect the Boundary
Step4: Finally insert the extracted boundary as a mask in the original image.

(a) **(b)**

Fig. 4 Edge Based Segmentation

Morphological Segmentation

Morphological Operation is a collection of non-linear operations applied to binary or grayscale images connected to the shape and size features of an image. This technique explores an image with a small shape or template called a structuring element.

Initially the gradient of the preprocessed image is obtained by applying Sobel operator. Then the gradient image is dilated and eroded twice to avoid the discontinuities in the edges. The extracted boundary image is masked on the original image which will display the affected skin lesion area. The result of the Morphological segmentation is shown in Fig.5. The procedure for Morphology based Image segmentation is given below.

Step1: Input the preprocessed skin lesion image.
Step2: Apply Sobel operator and get the Gradient Image
Step3: Dilate and Erode the gradient image twice.
Step5: Detect the Boundary.
Step6: Finally insert the extracted boundary as a mask on the original image.

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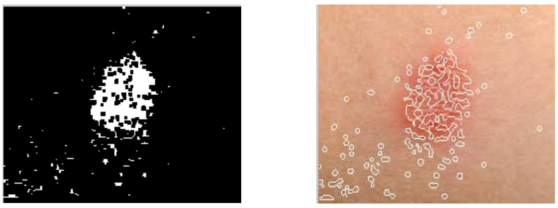

(a) **(b)**

Fig. 5 Morphological Segmentation

Cluster Based Segmentation

Clustering is a method to divide a set of data into a specific number of groups. K-means method, one of the efficient clustering techniques is proposed in this paper. It partitions a collection of data into a k number of disjoint clusters. K-means algorithm consists of two separate phases. In the first phase, it calculates the k centroid and in the second phase, it takes each point to the cluster which has nearest centroid from the respective data point. The procedure for k-means cluster based Image segmentation is given below.

Step1: Input the preprocessed skin lesion image.
Step2: Apply K-means Cluster Algorithm.
Step3: Convert Cluster Image → Binary Image
Step4: Detect the Boundary
Step5: Finally insert the extracted edge as a mask in the original image.

K-means algorithm:

Let us consider an image with resolution of $x \times y$ and the image has to be cluster into k number of cluster. Let $p(x, y)$ be the input pixels to be clustered and c_k be the cluster centers. The k-means clustering algorithm is given as:

Step1. Initialize the number of cluster k and centre.
Step2. For each pixel of an image, calculate the Euclidean distance d, between the center and each pixel of an image using the relation given below.

$$d = \|P(x,y) - C_K\| \qquad (2)$$

Step3. Assign all the pixels to the nearest centre based on distance the d.
Step4. After all pixels have been assigned, recalculate new position of the centre using the relation given below.

$$C_k = \frac{1}{k} \sum_{y \in C_k} \sum_{x \in C_k} P(x,y) \qquad (3)$$

Step5: Repeat the process until it satisfies the tolerance or error value.
Step6: Reshape the cluster pixels into image.

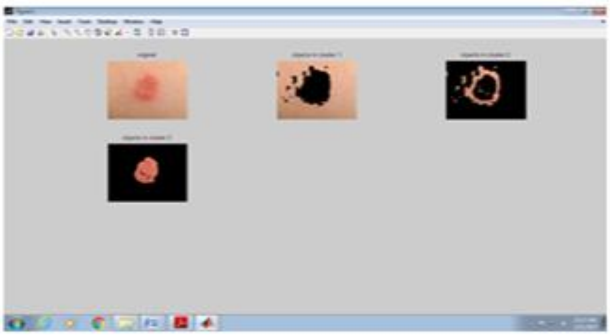

Fig .6 K-means Cluster Segmentation

The input skin image segmented by K-means algorithm contains three clusters (iterations) as shown in Fig 6. The clustered image is converted to Binary image and then *log* operator is applied to extract the affected lesion region. The clustered binary image and the extracted abnormal skin region are shown in Fig 7.

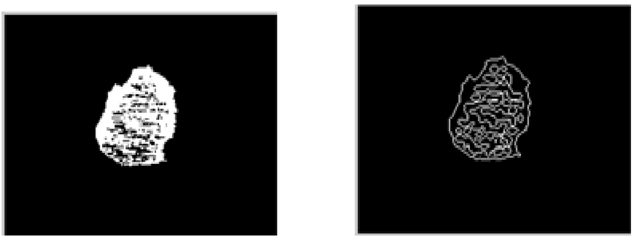

Fig7.a) Binary Clustered Image b) Extracted Lesion

Fig. 8 Detected Abnormal Skin Region

D. Feature Extraction:

Once the abnormal skin regions are effectively segmented, the diagnosis of the skin diseases depends on the features of the extracted regions. In this research work, the Statistical (Mean, Standard Deviation) and texture (Contrast and Energy) properties are calculated for all the three segmentation outputs.

Statistical properties:

The statistical measures mean and standard deviation are calculated as below:

Mean:

Mean is the basic statistical measure often used in geometry and analysis. It is the average intensity value of the pixels in the detected skin lesion image which is calculated by using the formula:

$$\mu_i = 1/N \sum_{j=1}^{N} f_{ij} \qquad (4)$$

Standard deviation:

Standard deviation is a most widely used measure of variability or diversity used in statistics. In terms of image processing, it shows how much variation or "dispersion" exists from the average (mean or expected) value.

$$\sigma_i = \left(\frac{1}{N}\sum_{j=1}^{N}\left(f_{i,j} - \mu_i\right)^2\right)^{1/2} \qquad (5)$$

Where f_{ij} is the value of the i^{th} component of image pixel j and N is the number of pixels in the image.

Texture Properties:

Texture is one of the most popular features used for classifying, diagnosing and identifying the skin diseases.

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GLCM (Gray Level Co-occurrence Matrix) is a statistical method used for the analysis of the skin texture. It considers the spatial relationship of pixels and characterizes the texture of a skin lesion region by calculating the occurrence of pixel in an image with specific values and in a specified spatial relationship.

GLCM is generated by using *graycomatrix()* function representing how often a pixel with the intensity (gray-level) value *i* occurs in a specific spatial relationship to a pixel with the value *j*. By default, the spatial relationship is defined as the pixel of interest and the pixel to its immediate right (horizontally adjacent). After GLCM is created, the properties like *contrast* and *energy* are derived by using *graycoprops()* function to analyze the texture [6][16].

Contrast:

Contrast will measure the spatial frequency of an image and is the difference of moment of GLCM. ie, it is the difference between the highest and the lowest values of a contiguous set of pixels. It measures the amount of local variations present in the image. A low contrast image presents GLCM concentration term around the principal diagonal and features low spatial frequencies.

$$Contrast = \sum_{i,j=0}^{N-1} P_{ij}\ (i-j)^2 \qquad (6)$$

Energy:

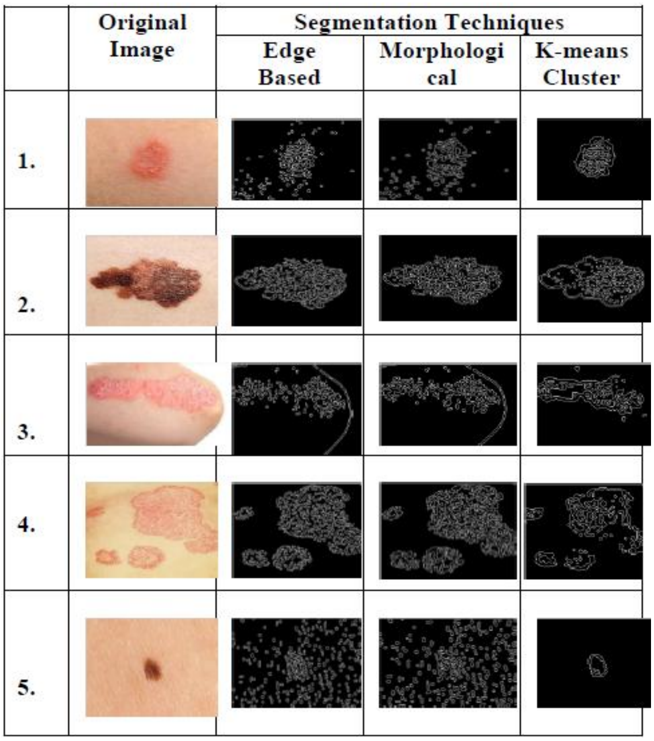
Energy is called as Uniformity or Angular second moment. It measures the textural uniformity that is repetitions of pixel pair. It detects disorders in textures. The maximum value of energy is equal to one. High energy values occur when the gray level distribution has a constant or periodic form. Energy has a normalized range. The GLCM of less homogeneous image will have large number of small entries. The energy is calculated as:

$$Energy = \sum_{i,j=0}^{N-1} \left(P_{ij}\right)^2 \qquad (7)$$

IV. EXPERIMENTAL RESULTS AND ANALYSIS

Various skin lesion images are acquired, segmented and the segmented skin lesions are given in Table 1. The K-means algorithm performs well when compared to other two methods which yield over segmentation.

Table 1 Result of Edge Based, Morphology Based, and K-means cluster Techniques



The Statistical and Texture Properties for the segmented skin lesion images of all the techniques are tabulated as below

Table2. Mean Value Calculation

Images	Edge Based M	Morphology Based Method	K-Means Cluster Based Method
Image1	0.04913479	0.04715392	0.02367942
Image2	0.07413333	0.07063704	0.05989136
Image3	0.05576451	0.05572492	0.04515401
Image4	0.10416501	0.10108791	0.08879933
Image5	0.08805816	0.09473434	0.00544792

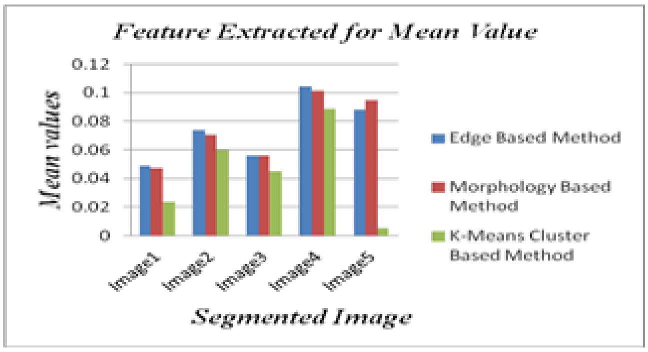


Fig. 9 Mathematical representation for Mean value

Table3. Standard Deviation Calculation

Images	Edge Based Method	Morphology Based Method	K-Means Cluster Based Method
Image1	0.2161494	0.21196798	0.15204836
Image2	0.26198775	0.25621758	0.23728545
Image3	0.2294664	0.22938974	0.20764182
Image4	0.30547449	0.30144509	0.28445388
Image5	0.28337947	0.29284765	0.07360868

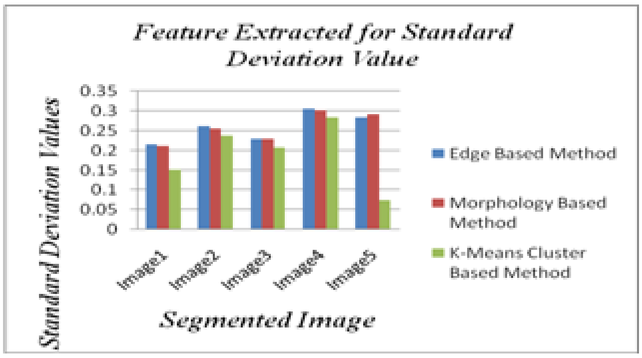


Fig.10 Mathematical Representation for Standard Deviation Value

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Table4. Contrast Value Calculation

Images	Edge Based Method	Morphology Based Method	K-Means Cluster Based Method
Image1	0.0596	0.0603	0.0305
Image2	0.0987	0.0956	0.0755
Image3	0.0775	0.0767	0.0544
Image4	0.1386	0.1361	0.113
Image5	0.1239	0.137	0.0076

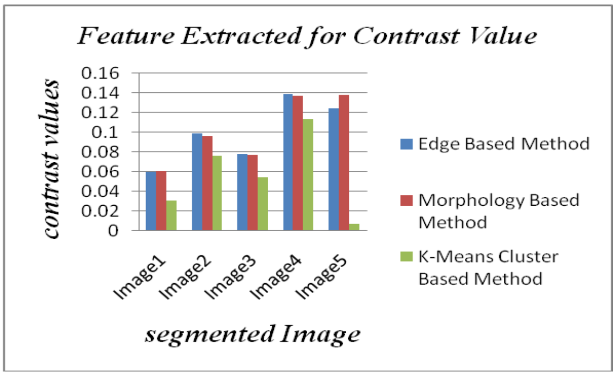

Fig. 11 Mathematical Representation for Contrast Value

Table.5 Energy Value Calculation

Images	Edge Based Method	Morphology Based Method	K-Means Cluster Based Method
Image1	0.8501	0.8531	0.9205
Image2	0.7732	0.7817	0.8171
Image3	0.8228	0.8236	0.8621
Image4	0.6934	0.7001	0.7374
Image5	0.7303	0.7097	0.9815

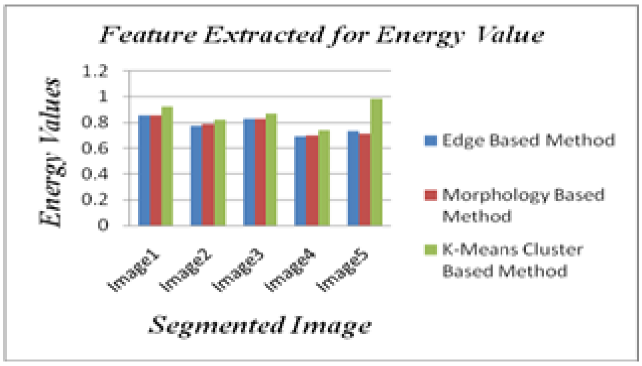

Fig 12. Mathematical Representation for Energy Value

Edge based segmentation, segments the abnormal region with less computational effort but result is over segmentation. Morphology based segmentation keeps the shape and size of the skin region but it also provides over segmentation. The K-Means clustering technique effectively identifies the abnormality in the skin region and performs well without any under or over segmentation. The values of mean, standard deviation and contrast are low and the energy value is high for K-means algorithm so that it avoids both over and under segmentation. But, the quality of the output depends on the arbitrary selection of initial centroid. If the initial centroid is randomly chosen, it will give different initial centers so that it should be carefully selected. The computational complexity of the K-means clustering relies on the number of data elements, clusters and iterations.

V. CONCLUSION AND FUTURE WORK

In the proposed method, different skin lesion Images are acquired segmented and the statistical features (Mean and Standard Deviation) and texture features (Contrast and Energy) are calculated. From the observed results it is clear that k-means segmentation gives better result compared to other two methods. The feature data set can be constructed and used to classify the abnormal regions to diagnose the skin diseases which will be the future direction of this work.

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