Journal of Science and Technology (JST)
ISSN: 2456-5660 Volume 4 Issue 2, March-April 2019, PP 20-29
www.jst.org.in

Algorithm for Skin Lesion Segmentation

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Abstract: *In most recent applications of image analysis, the difficulty faced is to detect proper structure of an irregularly shaped object. This is mostly seen in the applications of medical field such as skin lesion segmentation. It is also a critical task to determine the exact border line of the lesion. Also early detection of skin cancer is an essential problem in the recent years of development in image processing. There are many types of skin lesion appearances. Some of them are blurred, some are irregular in shape, some are on dark skin, and some are seen with lots of hair on the skin. The main aim of this research paper is to detect the malignant region of skin lesion, identify its stage, and segment it out from the skin image. During the process, it is essential to preprocess the input image by performing conversion of a color image to gray scale image, removal of blur, removal of noise, smoothing of images, etc. It also involves grouping the similar pixels into one cluster, likewise obtaining various clusters based on similarities. Then it is essential to perform the extraction of features of the lesion and displaying the segmented lesion. In the current research a novel approach is developed to obtain the clusters of any shape and is tested on skin lesion images for detecting the cancer cells. Performance of developed clustering algorithm is tested by measuring various parameters based on distance metric and few similarity indexes. The proposed method is also compared to other approaches that are developed earlier.*

Keywords - *Baroni-urbani and Buser coefficient;Dermo-scopes;FCM; Log-Gaussian; Jaccard's skin lesion segmentation*

I. INTRODUCTION

Clustering is the process of grouping unknown points into same class based on their similarityfeatures. It is an unsupervised task. The main aim of the approach is to partition the given set of points in a manner that various objects having similar featuresbelong to same class and that are different are grouped with a different class.Clustering is also an essential approach to extract the hidden objects. This is also found significance in data compression techniques.A general idea of clustering is that they are pattern-based ie., the various classes are represented as the prototypes M_i, i=1, 2, 3, , m. Thus each class is shown as

$$M = \{M_1, M_2, M_3 \ldots M_m\} \quad (1)$$

Each pattern M_j is an n-tuple vector with a center m_i. A major concern in pattern recognition is that extracting the similar or dissimilar data and grouping them. One such concern boosted many researchers to develop and implement various texture analysis approaches in image processing.In literature there are many approaches to perform clustering without affecting the nature of the desired image and also helpful for many texture analysis applications. It is mainly applicable to many areas in image processing such as, medical image analysis, remote sensing applications, face recognition, finger print recognition and identification. Clustering also forms the last step of image processing by extracting and recognizing the desired object according to the application. This paper discuss on the clustering approach applied to skin lesion feature extraction and segmentation. There are many approaches to perform so. In this research paper, a novel approach for lesion segmentation is proposed based on fuzzy clustering. The approach is developed as Fuzzy C varieties (FCV) combined with log Gaussian filter for better sharpening of the texture features.This paper is organized as 4 parts. Part II explains about the literature review of the various texture analysis methods. Part III discusses about the proposed method, its mathematical framework, evaluations by using suitable parameters and part IV shows the results using the proposed method and comparison with the conventional approaches.

II. LITERATURE REVIEW

III. Literature on fuzzy algorithms for texture analysis:

In the context of image processing texture segmentation is a critical task as thepriori knowledge of various features is not known. To perform segmentation, it is essential to know the existence of textures in various parts of the image. It is also necessary to discriminate both textures that are extracted. Texture classification is done based upon either similarities or dissimilarities. The approaches that use similarities of textures to group are termed as region based segmentation methods and that use dissimilarities are boundary detection approaches.

In the unsupervised classification approach [1] for texture segmentation based on fuzzy algorithm is explained and compared it with adaptive distance dynamic clusters (ADDC) algorithm. The author also explained that the both algorithms are compared based on Mahalanobis distance metric and concluded that the partition was effective and classification was up to the desired level.

The distance metric used in both algorithms is given as:

$$M_{ij} = \left|\varepsilon^{1/3}\right|\left(p_i - m_j\right)^T\left(p_i - m_j\right) \qquad (2)$$

Where m_j is the mean vector, ε is the covariance matrix of j^{th} cluster.

In the paper [2] the authors evaluated various fuzzy C-means algorithms based on a distance metric called Mahalanobis distance. They explained about improving the accuracy by using the mentioned metric which is done by using an additional separable criterion. The authors proposed two improved algorithms FCM-M and FCM-CM based on unsupervised Mahalanobis distance metric.The paper [3] explains about identifying the missing features or data from incomplete set of data. The identification process is done by improving Fuzzy algorithms using local principal component analysis of fuzzy covariance matrices. The approach uses an assumption that the defects are randomly exist. Also the method LPCAM is found to be more efficient in identifying the missing data.The authors in [4] presented two methods for the improvement of fuzzy covariance matrix in GK clustering algorithm. It deals about two approaches applied on data samples. They are,

1. The first approach involves in calculating the ratio between the maximal and minimal Eigen value of the covariance matrix.
2. The second approach involves in extracting Takagi-sugeno fuzzy model from the data.

The work in [5] deals about application of FCM to classify data by reducing an objective function. Here the objective function is based on Kullback-Leibler divergence instead of the entropy. From theabove literature it is evident that extracting feature and also segmenting a desired object can be done in many fuzzy approaches. Every approach has its own merits and demerits. In recent years also many researchers are working on such problems in various fields of image processing. One such vast field is biomedical image processing. Texture analysis plays a vital role in medical applications for tumor detection, cancerous cell detection, color texture segmentation etc. Skin cancerdisease is often seen in many parts of the world. It is also critical and difficult to identify in early stages. Now-a-days research is going on in such domain areas. This problem is also categorized as parametric texture analysis and it is an essentiality to develop recent and updated algorithms for its detection and identification. Many previous works are also found in literature to extract the cancer cell pixels. Some of the approaches are Gaussian mixture model, random vector field, wavelets, Gabor filters, etc. In this paper, it is made clear that modified fuzzy C-shell clustering is combined with log-Gaussian based filters to yield good results on segmentation of the malignant cell. The performance is evaluated on the basis of Jaccard's similarity index, Euclidean distance, Baroni - Urbani and Buser coefficient index. The comparison is made among each other and also for various conventional methods.Before extending the discussion on proposed method, some literature on skin lesion segmentation is discussed and is given below

B.Literature review on skin image segmentation:

The problem addressed in the paper [6] is that tumor extraction from MRI scanned brain images is efficiently performed by Enhanced fuzzy C-means algorithm. Performance evaluation is done based on the parameters such as accuracy rate and error rate of the tumor. It is also concluded that EFCM is having low performance indices. An automatic skin lesion segmentation technique is proposed and developed in [7] stating that a semi supervised technique is developed, which is termed as K-means clustering for grouping all cancer cells with an unique value and class. Also these cells are filtered based on the feature such as color. The overall score obtained by using this approach is 0.548. A novel approach for skin lesion segmentation is developed in [8]. This approach is based on wavelet transform combined with morphological operations. The performance evaluation is done using certain indexes like Average true detection rate (ATDR), Average False-Positive rate (AFPR), Average error probability rate (AEPR). For accuracy, DICE similarity index is used,

$$DICE = \frac{2\,Area(AD \cap MD)}{Area(AD) + Area(MD)} \qquad (3)$$

This paper concludes that proposed algorithm faced difficulty in detecting hair on the skin and their removal. But a better approach may give good segmentation results if hair detection and removal is done. Another main concern in image analysis is poor resolution. The main aspect is to improve the resolution by using appropriate method. One such approach is developed in [9]. Wavelet analysis is found to be advantageous for such applications. The recent approaches explained in [9] are, Discrete Wavelet Transform (DWT), Stationary Wavelet Transform (SWT), Dual tree complex wavelet transform (DT-CT). A DWT-NLM is developed to enhance resolution of the image. It makes use of Lanczos filter which produces minimum aliasing and ringing effect. The performance evaluation is done by measuring MSE, PSNR and Q-factor. In [11] three unsupervised segmentation approaches have been developed to yield better results. They are Otsu's method, Gradient Vector Flow (GVF) and color based image segmentation using K-means clustering.

III. PROPOSED METHOD

The proposed methodology is developed from the initial stage as image acquisition to final stage of feature extraction.

Step 1: In image acquisition step, the skin images are acquired from various kinds of dermoscopes. These are shown in Fig. (1)

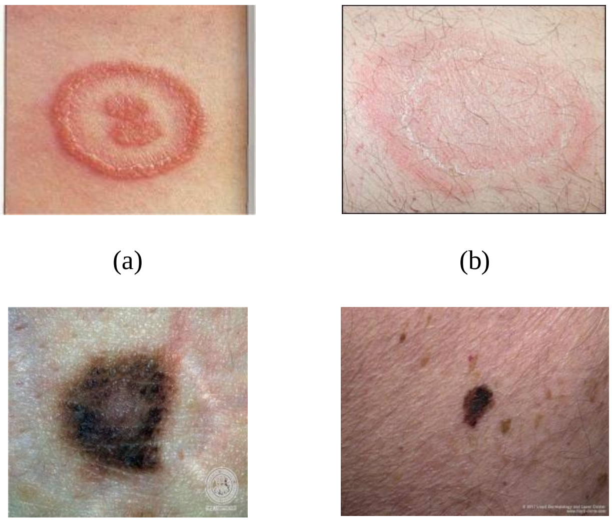
Fig.1. various dermoscopes

Step 2: The next step is pre-processing the acquired image. This involves eliminating all artifacts or sharpening the image using some filter techniques. This may also involve in improving the appearance, noise removal is one such mostly seen artifact and the presence of hair around the cancerous lesion. Removing this artifact is also one of the significant aspects in performing pre-processing step. This can be done either by using mathematical morphological approach or certain type of filters to smoothen and sharpen the image.

Fig.2Dermoscopy image with (a) hair, (b) oil bubbles, (c) low contrast

The other requirement of pre-processing is to change one color space to the other such as RGB to gray or RGB to lab etc.

Step 3: This step involves in detecting the nature and shape of the lesion on the skin. This is done by various segmentation approaches. Most of the algorithms used for segmentation are “cloud like” clusters. Many variations of Fuzzy C means Clustering (FCM) and Possibilistic clustering (PCM) are proposed and they detect the objects of shape such as lines, circles, etc. But in image analysis still more complex structures are seen such as shown in Fig.3.



(a) (b) (c) (d)

Fig 3 Types of skin lesions

Fig.4 Skin image with circles, random, pigmented image

Fuzzy C shells clustering approaches are used to detect such random structures. In the current paper a novel algorithm is developed to detect such shapes and perform certain pre- and post-processing for better result. It is named as Log-Gaussian Fuzzy C means clustering (LGFCM). In this the Fuzzy C means clustering approach with appropriate cost function and variety of distance metric is combined with a logarithmic Gaussian high pass filter and is used to sharpen the edges and thus helpful in detecting any such sharp edges. The mathematical formulation of such approach is discussed below.

A Mathematical formulation of LGFCM:

Fuzzy C-Clustering:

Fuzzy C means clustering is the most commonly used soft segmentation algorithm that yield best results in performing partition of images.

The cost function used for FCM is given as:

$$C = \sum_{j=1}^{r}\sum_{i=1}^{s} v_{ij}^{m} D_{ij}^{2} \qquad (4)$$

Where

s = number of pixels in the image

r is the number of clusters

m is the weighting factor

D_{ij} is the distance between pixel of concern and j[th] prototype cluster.

v_{ij} is the Fuzzy membership of x_i.

x_i is the data of interest.

The constraint imposed on given algorithm is

$$\forall_i, \sum_{j=1}^{r} v_{ij} = 1 \qquad (5)$$

To get optimal results and error free output the equation is performed iteratively.

A. Mathematical formulation of Gaussian high pass filter:

Filtering plays a significant role in image processing. It is used not only for noise removal but also to smoothen (LPF) and sharpening (HPF) of the images.

Rather than using an ideal filter it is evident to use an approximated filter for better results and reduce complexity. Gaussian high pass filter is such an approximation to ideal high pass filter, which performs to detect the sharp edges. It is mathematically given for images as,

$$Gu(x, y) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(x+y)^2}{2\sigma^2}} \qquad (6)$$

Gaussian high pass filter is used to eliminate the features that are near to the center of the image. Ringing effect is removed.

The LGFCM is formulated as

$$U_{\lg fcm} = \sum_{j=1}^{r} \sum_{i=1}^{s} v_{ij}^m D_{ij}^2 + \log(GU(x, y)) \qquad (7)$$

IV. PERFORMANCE EVALUATION

Many similarity metrics have been developed to test the performance of the developed approach. The proposed method also evaluated using various binary symmetric approaches.

Some of them are Euclidean distance, Jaccard's coefficient and Baroni-Urbani&Buser coefficient.

Euclidean metric is defined as:

$$ED = \sqrt{(p-s)^2 + (q-n)^2} \qquad (8)$$

The value of ED ranges from 0 to ∞.

Jaccard's coefficient is used to determine how similar each pixel in different images is. It is mathematically given as:

$$JA = \frac{p}{p+q+r} \qquad (9)$$

Where p, q, r are the pixels belonging to the clusters formed.

Baroni-Urbani and Buser coefficient is used for finding negative similarities. It is given as:

$$BU = \frac{\sqrt{ps} + p}{p+q+r+\sqrt{ps}} \qquad (10)$$

The BUB coefficient ranges between 0 for no match and 1 for a match.

V. RESULTS

The methods are tested with skin lesion images from DERMIS and DERM Quest web and are tested for more than 500 images. For understanding few of them are shown below. Various parameters are measured and discussed for them.

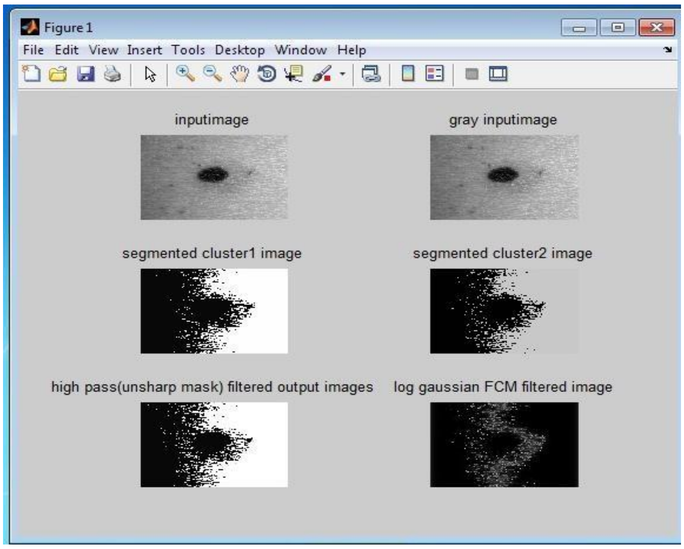


Fig.5 LGFCM output for image1

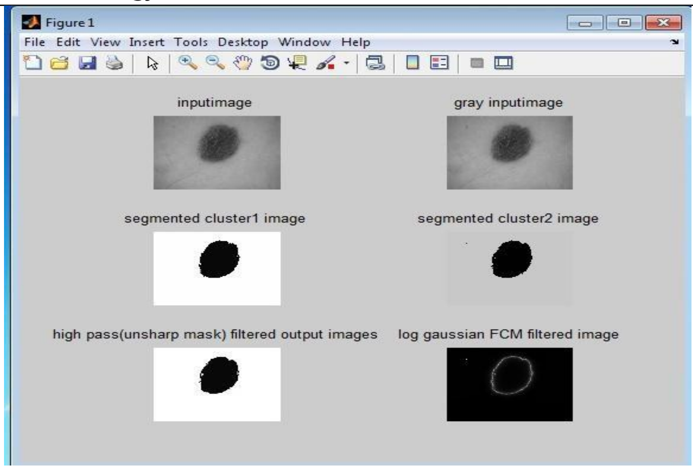


Fig 6: LGFCM output for image2

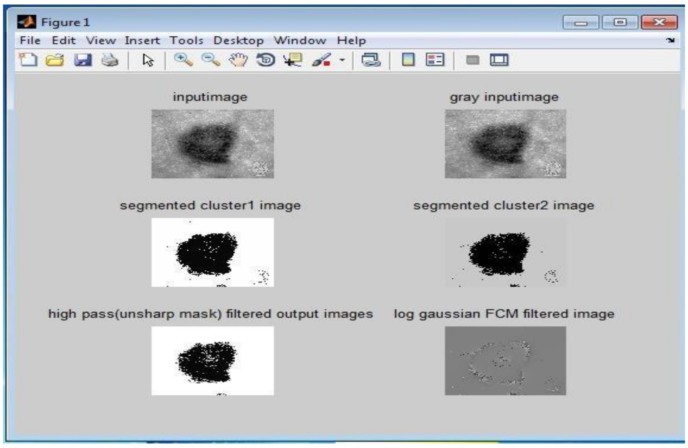


Fig.7 LGFCM output for image3

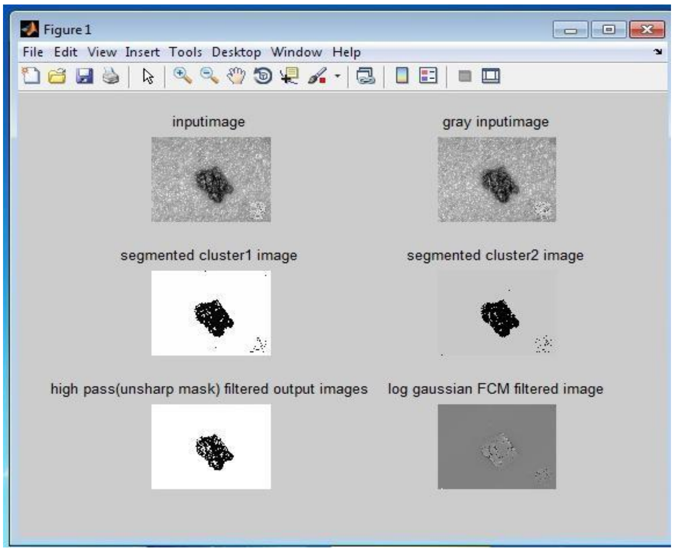


Fig. 8 LGFCM output for image4

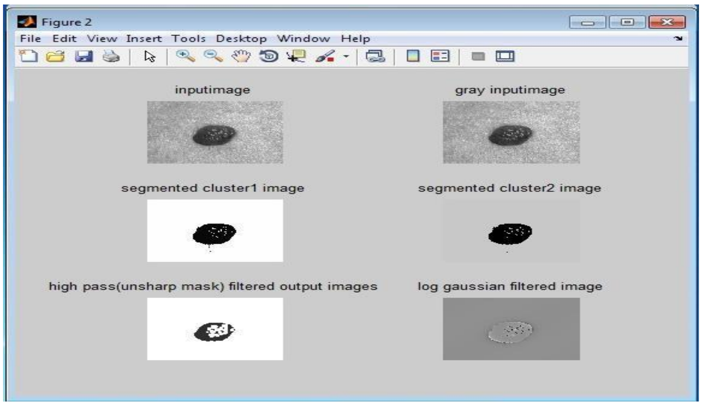


Fig. 9 LGFCM output for image5

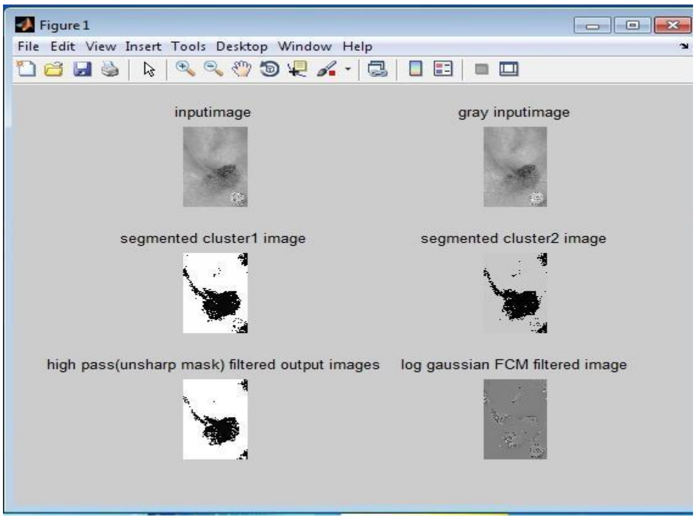


Fig. 10 LGFCM output for image6

Table 1: The parameter measurements for various tested images

Image	Clust1	Clust2	Jaccard's dist.	Euclidean dist	BUB coeff
Image1	123.093	177.692	2.3e-006	2.09e+006	1
Image2	72.67	148.37	0	9.0e+004	1
Image3	64.9687	162.516	4.2e-005	3.03e+005	1
Image4	69.90	171.687	2.1e-005	3.2e+005	1
Image5	70.1744	176.805	0	8.63e-004	1

Image6	121.880	164.233	0	2.5e+005	1

IV. CONCLUSION

From the results obtained it can be observed that LGFCM yields better results with good similarity indexes compared to conventional approaches. The edge of the lesion is exactly located without any loss of generality. In future the work may be extended to detect the skin lesion oriented in a random shape using varieties of FCM such as FCM shell clustering approaches, wavelets and PCA for early detection of the malignant melanoma effects.

ACKNOWLEDGMENT

The authors would like to thank the management of K L University for providing all facilities in the campus to carry out the research work.

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