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An Optic Disc Segmentation in Retinal Images using Efficient Clustering method

By

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ABSTRACT

Optical disc segmentation is essential stage for retinal image analysis and disease identification. Segmentation locates the optic disk in the retinal fundus images. Various researchers have triad for improving the efficiency of the optical disc segmentation. Pprincipal component analysis based method is popularly used but are computationally complex. Thresholding is also widely used for improving the efficiency of the disc detection method. But under diabetic patient there efficiency degrades. Fuzz C means clustering is also used by some researchers but the efficiency is the major concern under optical imaging environment. This paper presents a new method of optical disc segmentation using the K mean clustering in retinal images. Study of thresholding based methods for optical disc segmentation is presented. It is observed that the method of disc detection should be less complex and efficiently works for all kind of images.

General Terms
Retina, Fundus, Image Processing, Morphology

Keywords
Optical Disc Segmentation, Enhancement, Segmentation, Thresholding, Clustering,

1. INTRODUCTION

Technological growth has made it possible to design sophisticated retinal image capturing cameras and methods. But still it is required to initially process the captured image for noise and visibility improvement. The retinal fundus images are widely used in the treatment and analysis of a variety of eye diseases such as glaucoma and diabetic retinopathy disease. A computer vision based fundus retinal image analysis may lead to detection and characterization of retinal features prior for higher level inspection. Segmentation of eye fundus images plays an important role for finding the shape, size and position of the optic disc identification of abnormal growth regions in the eye. The Figure 1 shows the components of a retinal fundus image of human eye. It is clear that Retina is the interior component and is directly contacted to brain nerves system via optical disc. An optic disc is considered as the brightest component of the retinal image and can be identify and represented as a pale is a round or vertically slightly oval shape. It is the doorway to the blood vessels and optic nerves into the retina. This disc often used as a landmark and reference point for calculating other features in the fundus images. Usually optical disc segmentation methods suffer from various difficulties levels like insufficiency of filtering and thresholding [1]. Therefore, optical disc segmentation is a challenging field for the researchers.

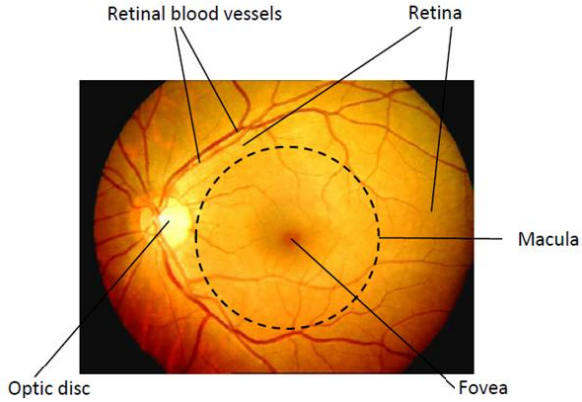

Figure 1 **Components of fundus human eye**

1.1.Classification of optical disc Segmentation

There are various methods [1, 4, 7 and 11] which have been designed by many researchers for better segmentation of optical disc. The broad classification of the optical disc segmentation methods are given in the Figure 2. Thresholding is widely used method for optical disc segmentation [2, 3, and 4]. There are different types of thresholding methods based on the kind of feature in the images. Global thresholding is a popular method out of all. The principal component analysis (PCA) [19, 20] is another widely opted optical disk analysis method. The Fuzzy c means clustering [5, 1 and 24] is also

adapted by few researchers for segmenting the disc using proper cluster selection.

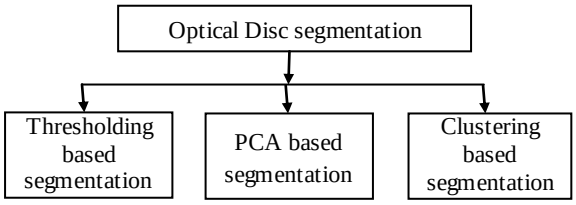

Figure 2 Classification of optical disc segmentation

Contrast limited adaptive histogram equalization (CLAHE) enhancement method by Etta D, Pisano was designed for improving the image contrast as in [5] for medical imaging applications to overcome noise and blurriness problem. Hitam *et al.* [20] have presented an underwater images enhancement by merging CLAHE enhancement in RGB space and CLAHE enhancement in HSV color spaces. Agung W et *al.* [4] have proposed using CLAHE method for enhancing the colour retinal images using the (green) G channel. In the colour retinal image a unique characteristic exist than other medical images that these images in green (G) channel, the blood vessels looks more contrast than the background.

2. MAJOR CHALLENGES

The limitations of existing methods can be stated as following challenges or problems.

- Many existing OD detection methods used histogram based techniques viz. Histogram Equalization (HE) or Contrast Limited Adaptive Histogram Equalization (CLAHE) to pre process the images. But these methods suffer from the major problem of colour shifting due to brightness variation. Thus under the presence of noise in the image the efficiency of these method degrades slightly.
- The existing clustering based methods are effective for only healthy retinal images. Therefore, it is needed to improve efficiency of probabilistic nature of the fuzzy clustering methods.
- Morphology based segmentation is common for the identification of optical disc. But every method used the varying size of the mask (as 1 to 5). So it requires comparing and analyzing the performance of various mask sizes for optical disc location.
- The blood vessels on optical disc regions may cause the poor segmentation efficiency. So, many methods have used before segmentation for removing them. But most of them are either computationally complex or inefficient.
- An efficient threshold selection is a major problem. Many of automatic thresholding methods may not perform well for different types of the retina images. Since position of the optical disc varies in the retinal images

3. SEGMENTATION METHODS

There are various optical disc segmentation methods in literature. In this paper we are reviewing the three widely used methods.

3.1 Thresholding Algorithm

Thresholding is separation of darker background from brighter foreground for gray images. The coordinates of pixels with the maximum brightness are identified as x and y in the enhanced image. Then the histogram is plotted for gray level $f(x,y)$. Now the segmentation is perfumed by selecting the global threshold and the segmented image is given as;

$$g(x,y)=\begin{cases} 0 & \text{if } bw(x,y)<Th \\ 255 & \text{if } bw(x,y)\geq Th \end{cases} \quad (1)$$

Where, $g(x,y)$ is a logical segmented image.Example of thresholding is shown in Figure 3. A threshold selection algorithm as follows:

```
mb=max(max(bw))        % finding maximum gray value
[ro co]=find(bw==mb);  % finding size of disc region
ro=min(ro) ;  co=max(co);  [row col] =size(bw) ;
  for n=1:1:row          % Thresholding for Logical image
     for m=1:1:col
        if bw(n,m)<=180 ;
           bw(n,m)=0 ;
             if bw(n,m)>=180 ;
                bw(n,m)=255 ;
               end
            end
        end
  end
```

a) Optical_image_2 b) Threshold image

Figure 3 Thresholding for optical_image_2

3.2 Clustering based Segmentation

Clustering methods sub divide the image area into segments based on the certain feature most probably colors. There are two basic clustering based methods Viz.

- Fuzzy C means Clustering and
- Fuzzy K means Clustering

Fuzzy C means Clustering

The FCM algorithm is as follows;

1. Fix the value of the number of clusters C
2. Select the initial value of c the clusters centers where c should be $(2 <= c < n)$.
3. Then set the value for parameter 'm' for exponent.
4. Initialize the partition matrix U(0). Each step in this algorithm will be labeled as 'r' where r = 0, 1, 2 …

Fuzzy K means Clustering

This method partitions the objects into K clusters which are mutually exclusive. In a input optical image, this method initializes the desired K number of clusters and initial set of k initial random starting points, Clustering algorithm calculates the clusters centroids and distance matrices and based on their analysis desired number of distinct clusters.

3.3 PCA Based Segmentation

The principal component analysis (PCA) is frequently used in early optical disk analysis methods. Huiqi Li et al.[19] in 2001 proposed to automatically locate optic disk in retinal images. Desired region in intensity image is first determined by clustering brightest pixels. Then PCA analysis is then applied to clustered candidate regions. Minimum distance between original retinal image and there projection onto disk space is

located as centre of the optic disk. But method was time consuming.

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4. PROPOSED DISC SEGMENTATION METHOD

This paper focuses to use the clustering based optical disc segmentation method. The efficiency of the segmentation is essential for optical disc localization and identification so, paper proposes to improve the K means clustering efficiency by using the wavelet based cluster fusion.

4.1 Proposed Pre Enhancement Method

The pre enhancement method is a combination of the image processing tasks as follows;

1. Resize the optical retinal image to 240 x 320, size for performance evaluation at equal size of different optical images and the existing methods. There is no image enhancement method used.
2. Convert the RGB color image to the LAB color space. And then separate the luminance component L and select only A and B chrominance signals. The Lab color space is used since it avoids the use of the contrast enhancement stage in optical disc segmentation processes. It is because the optical disc is better represented by the A and B component of the LAB image.
3. Removing the optical nerves using morphological processing techniques. For improving the optical disc segmentation efficiency.

The process of blood vessels removal is shown in the Figure 4.

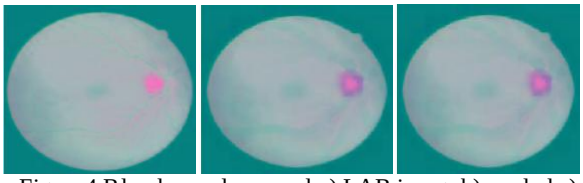
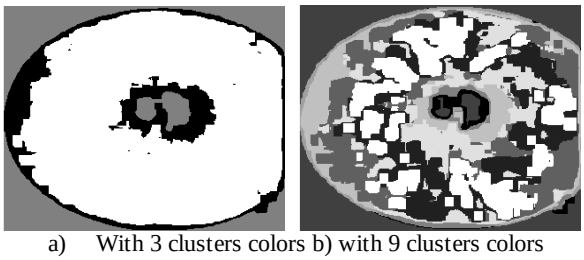


Figure 4 Blood vessel removal a) LAB image b) eroded c) dilated eroded with blood vessels removal

4.2 Clustering based Segmentation

The optical image pixels are defined as data samples before clustering them. Define the feature vector $(Fi1, Fi2, Fi3, \ldots\ldots\ldots, Fim)$ where Fim is the value of the M dimensional space. As in the other clustering algorithms, K-means requires that a distance metric between pixels is to be defined. The Euclidean distance metric is used to calculate the C in above mentioned step (4) of the algorithm. An Example of the optical disc image with K clusters is shown in Figure 5.



a) With 3 clusters colors b) with 9 clusters colors
Figure 5 Disc Clustering with K means Clustering

5. EXPERIMENTAL RESULTS

The results of Fuzzy K means clustering based segmentation methods are presented. Paper proposes to use wavelet fusion for improving the efficiency of the clustering based segmentation. Determination of fundus images parameters for segmented image is presented. It is found that proposed method is capable of segmenting the disc better and works well for all kind of optical image datasets as shown in Figure 6.

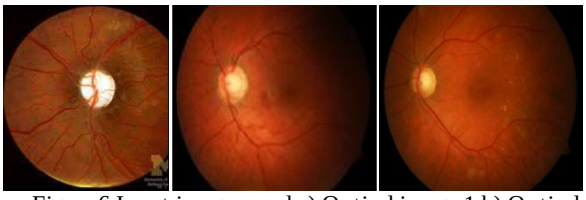
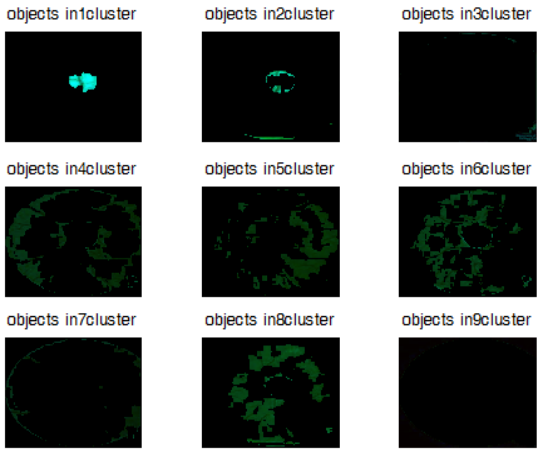


Figure 6 Input images used a) Optical image 1 b) Optical image 2 c) Optical image 4

5.1 Results of Optical Disc Segmentation

This section presents the results of the segmentation of optical disc using proposed K means clustering method. This takes the number of colors K as input and segments the input image into K different pats each containing the one of K colors as feature. Results of the 9 segmented clusters using proposed K mean clustering method is shown in the Figure 7a). The optical disc may be part of many clusters therefore it is proposed to fuse the desired clusters using wavelet based fusion as shown in Figure 7 b-d) for optical image 4



a) segmented 9 clusters for optical image 4

b) Segment 1 c) Segment 2 d) Fused Threshold image

Figure 7.Result of the K means clustering based optical disc segmentation and Fusion for Optical image 4

It can be concluded that the proposed method segments the optical disc better under the presence of optical nerves as clear from the Figure 8 for optical image 1 and optical image 4. And the efficiency of the disc detection is more for these cases.

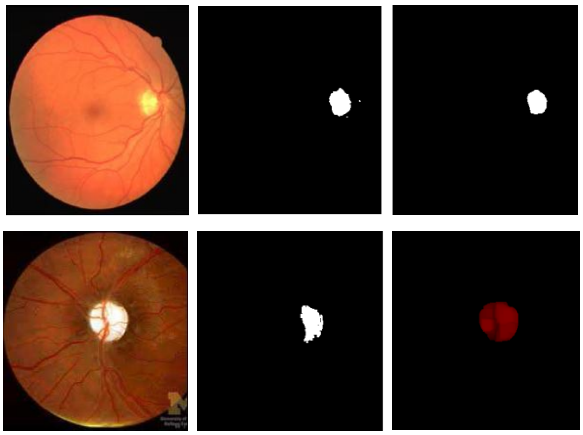


Figure 8 Results of existing and proposed segmentation methods a) left column input images b) middle is the global threshold results [2] c) right is the proposed K means and fusion based segmented image.

6. CONCLUSION

Efficient clustering based optical disc segmentation method is designed using K mean clustering and wavelet Fusion. It is found that thresholding based methods cannot segment actual optical disc and suffers under non uniform brightness and for the overlapping optical nerves over the disc.

It is concluded that efficiency of FCM based method fluctuates under the different kind of corrupted optical disc images Viz. diabetic images or images with multiple connected regions. The LAB color image is proposed to use instead of RGB color space. It is found to be efficient than normal thresholding based method.

It is found that combination of k-means clustering and the fusion of clusters improves the accuracy and performs better for all kind of images.

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