Preliminary and Multi Features Localisation of Optic Disc in Colour Fundus Images

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ABSTRACT

In computer assisted analysis of colour fundus images, an important prerequisite for the detection of exudates and blood vessels is the localisation and segmentation of the optic disc. In this paper, we propose a novel algorithm for optic disc localisation. It combines various image processing approaches: Unsupervised Colour Thresholding, colour similarity measure based on distance function and co-occurrence matrix. The object of optic disc in colour fundus images is searched based upon three main properties: yellow in colour, obscurity of main blood vessels and size less than 1/8 of retinal image. The algorithm is tested on 150 colour fundus images and their respective centre point is compared with the ground truth images. The results demonstrated that the proposed algorithm is able to provide a reliable and robust in detection of optic disc's centre point automatically.

KEYWORDS

Optic disc, co-occurrence, unsupervised colour thresholding

1. INTRODUCTION

In analysis of colour fundus images, there are some features that are crucial to be detected such as blood vessels, optic disc and some other lesions which provide useful clue for better understanding of the cause of blindness. One of the significant features is the optic disc. It is the entrance part of blood vessels and optic nerve from the brain.

The detection of optic disc is critical in retinal image analysis for further diagnosis of eye related diseases. It is always the very first stage in many diagnosis systems designed for automatic detection and extraction of anatomical and pathological structures. For instance, the diameter of optic disc is marked as the reference to measure distances between optic disc and macula [1]. It also serves as the seed or starting point for blood vessels tracking since the main blood vessels originate from the optic disc region [2] and [3]. Due to similar yellow colour appearance of the optic disc and the exudates, misclassification of optic disc as exudates can be avoided by detecting the optic disc first and masking it out from the rest of the yellow regions which may then be classified as exudates [4]. Therefore, the very first step of colour fundus images analysis is the optic disc localisation, a process which a highly potential candidate region of the optic disc and its centre location.

With the aforementioned importance, the task of accurate localisation of optic disc object is an essential. However, the task faces big challenges during optic disc localisation. One of them is the region of optic disc is fragmented into smaller and varying shapes regions as obscured by the traversed blood vessels. It turns the task of obtaining the best potential of optic disc difficult. The optic disc object which located at the nasal part appears less illuminated or dim yellow compared to temporal part of colour fundus image. This may misleads the choice of potential candidate of optic disc as the exudates exist in brighter yellow colour or higher illumination. Apart from that, the optic disc object that partially visible (not in completely circular) as it appears at the border part of the colour fundus image cause the task of localisation even harder. Variability in colour appearance is also one of the challenges that may mislead the selection of best potential of optic disc. It cause some of the optic disc objects appear as dim yellow or dim red, but not the most similar colour to yellow. The existence of artifacts during the image acquisition produces the white patches with high illumination at the border or center part of the colour fundus image in which may mislead the identification of optic disc object as well.

Therefore, the objectives of this paper are to devise an automated optic disc localisation algorithm. It incorporated three important features namely colour, obscurity by blood vessels and minimal size of optic disc. This paper also aims to design a reliable measure of each of the selected feature of optic disc.

2. RELATED WORK

Some of the existing approaches use only one feature for optic disc identification, while some approaches use the combination of various features to identify the optic disc object accurately, Huiqi and Opas [1] use the high illumination as the primary feature to initially search a list of potential optic disc with gray level clustering, Lalonde et, al. [5] also employs the same feature to locate a possible candidate of optic disc with pyramidal decomposition, Hoover and Goldbaum [6] proposed a localisation algorithm with fuzzy convergence approach to locate the centre point of optic disc. Fuzzy convergence is applied to search for origination or convergence of blood vessels, which is be one of the features of optic disc, Alireza Osareh et al [7] used a reference template model of the optic disc to search for potential optic discs. The intensity (illumination) image of optic disc from selected images are averaged and assigned as coefficient of template model. Their method is based on maximum similarity match between template model and the candidate region. Alireza Osareh et al [4] reported a series of algorithms to estimate the centroid of optic disc with both illumination and circularity. Fuzzy C-means clustering is employed as classification based on similarity in term of image function. It is followed by classification based on proximity using connected component labelling [8]. A compactness criterion is then applied to reject all exudates regions except for circular or ellipse shapes of the optic disc. Centre point of optic disc is estimated using an iterative algorithm [9].

The proposed optic disc localisation algorithm differs from the previously proposed algorithm in that a combination of various features, such as colour, obscurity of blood vessels and minimal size of optic disc. The proposed algorithm is tested on 150 images with a variety of retinal diseases and artifacts.

3. PROPOSED ALGORITHM

In most of the colour fundus images, optic disc is always observed as the brighter yellowish region at the temporal part, compare to nasal part. This is one of the representative characteristic of the optic disc object. Thus, this feature is used as the primary feature in proposed algorithm. Optic disc object is the entrance part of the major blood vessels which supply the oxygen and nutrition to tissues and cells of the eye organ. As the blood vessels reached within the region of optic disc, they turn and exit through the optic disc. Therefore, optic disc is the only region that contains or traversed by a large number of major blood vessels, compared to other portions of colour fundus images. With this feature, it is used as the second criteria in selecting the best potential of optic disc object. Size of optic disc is also one of the trivial features. The size of optic disc is approximately eighth of size of correspond colour fundus image or smaller. This is based on observation of available fundus image database. The minimal size of optic disc is also incorporated into selection criteria for optic disc detection.

The series of operations to localize the optic disc consists of: Image pre-processing; Identifying the candidate region of the optic disc; Obtaining the centre point of the best optic disc candidate.

3.1 Image pre-processing

The fundus image is smoothed with Gaussian smoothing to reduce noise and small features such as tiny blood vessels and other small features into more homogeneous regions. Smoothing is performed by applying the Gaussian kernel on three colour channels separately, i.e., the red, green and blue channels.

3.2 Identifying the candidate region of optic disc

Unsupervised colour thresholding is applied on a smoothed image to initially classify the colour fundus image into a number of colour clusters. Each cluster is represented by specific pseudo colour as shown in Figure 1. Unsupervised colour thresholding is a multithreshold segmentation procedure that involves a simple thresholding in each colour domain. The multithreshold is generated by means of within class and between class criteria from the relevant colour band. The unsupervised colour thresholding has been used in automated text detection and recognition in video images and the detail can be found in [10]. It is shown to be effective in reducing the background complexity while retaining the important features of text characters.

After the unsupervised colour thresholding, clusters are weighted based on how similar the colour of correspond cluster to reference yellow, where the cluster with the most similar to the reference yellow is assigned a highest value. In this procedure, the reference yellow colour is the averaged colour of optic discs, chosen from a number of healthy colour fundus images.

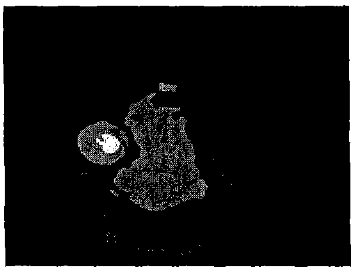

Figure 1: Each generated cluster is represented by pseudo colour

Even though the cluster with the highest weight or most similar colour to yellow, it is not always represent the optic disc object. It may be the case where the exudates appear in brighter yellow colour than optic disc, as shown in Figure 2. In some colour fundus images, optic disc may also observed as dim yellow or dim red, as illustrated in Figure 3.

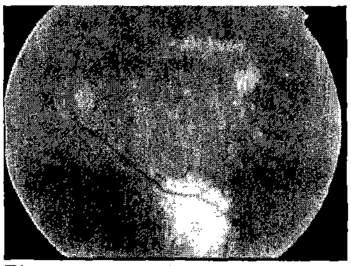

Figure 2: Exudates appear in brighter yellow than optic disc object

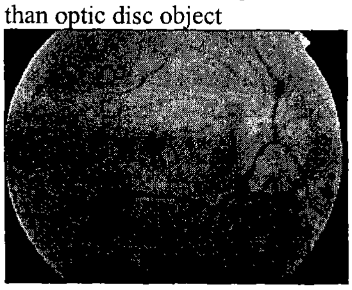

Figure 3: Optic disc appears in dim red in colour fundus image

Thus, depending solely on colour feature is insufficient to select the best correct candidate of optic disc. A second feature based on the level of obscurity of blood vessels within a neighborhood is used. In this step, the co-occurrence matrix is used to determine the obscurity of blood vessels within clusters. Co-occurrence matrix method is based on the repeated occurrence of some image intensity configuration in a rectangular window. A co-occurrence matrix and its computation scheme are given in Section 14.1.2 and Algorithm 3.1 respectively in [8]. In the fundus image, optic disc region shows high obscurity as it traversed by a huge number of blood vessels .The high intensity levels of pixels constituting the optic disc and low intensity of the pixels constituting the blood vessels contributes to certain fine structure compare to other regions. For clarity, in Figure 4, a red box contains vessel-like structure exhibits a fine structure compare to other yellow boxes.

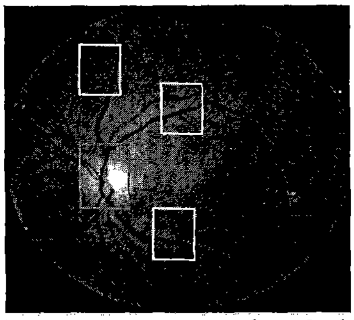

Figure 4: An example of showing various structures in different areas. The red box shows more vessel-structures than yellow boxes

Thus, this structure can be detected and measured by co-occurrence matrix. Any cluster that has high obscurity due to blood vessels is given a higher weight whereas a cluster with homogeneous pixels is then given a lower weight.

Finally, weights for each cluster obtained from yellow colour similarity and obscurity of blood vessels are summed. The cluster with the highest total weight will be selected as the best candidate of the optic disc. However, before the selection of candidate of optic disc is made, any cluster with the size larger than 1/8 of the size of retinal image will be removed.

3.3 Obtaining the Centre Point of Candidate of Optic Disc

The centre point of the chosen cluster in then calculated using the centre of gravity (COG) [8], a measure which is calculated using the moments of clusters.

4. RESULTS

The quantitative measure of optic disc localisation is based on paper [6]. The outcome of optic disc localisation is deemed true detection if the obtained center point is within the optic disc area. On the other hand, the detection is considered false detection if the obtained is away from optic disc area. Figure 5 shows the results of optic disc localisation in some fundus images and Table 1 tabulates the number of true detection in 150 colour fundus images.

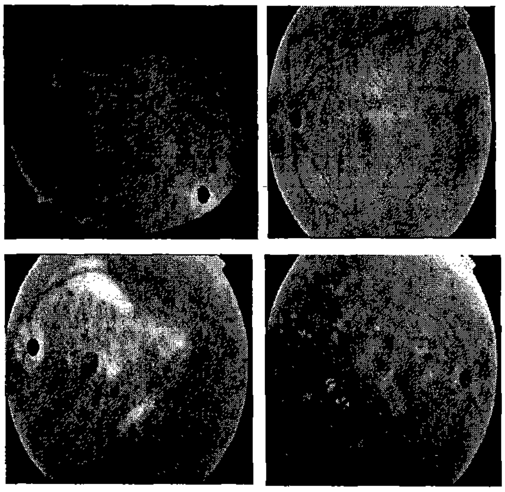

Figure 5: The obtained center point from proposed optic disc localisation algorithm is marked with blue dot

number of fundus images	number of true detection	number of false detection
150	135 (90.00)%	15 (10.00)%

Table 1: Summarized result of the proposed optic disc localisation algorithm

5. CONCLUSION

This paper had presented a novel algorithm to automatically detect and localize the centre point of the optic disc region in colour fundus images. The proposed algorithm employed multi features which are the colour of the optic disc (primary feature), the obscurity of vessel (secondary feature) and minimal size (third feature). The proposed algorithm was tested on 150 colour fundus images with a wide variation of lesions and other confusing artifacts; it is able to perform successfully in 135 out of 150 images. It is believed that accuracy of optic disc localisation would be beneficial to optic disc segmentation. It could serves as a preparation stage to automatic initialize the segmentation approaches such as deformable template or active contour on optic disc region. Even though it is only 90% percentage of true detection, but there is still room for improvement. Thus, future work includes exploring other feature representation of optic disc and better approach to measure each of the features will be explored.

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